

FINAL

2016 Year 22 Monitoring Report

East Harbor Operable Unit Wyckoff/Eagle Harbor Superfund Site

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List of Acronyms

ARI	Analytical Resources, Inc.
B[a]P EQ	benzo(a)pyrene equivalence
bms	below mud surface
cm	centimeters
cf	cubic feet
COC	chemical of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	cleanup screening level
cy	cubic yard
DGPS	differential Global Positioning System
DoD	Department of Defense
DOH	Washington State Department of Health
DRO	diesel-range organics
dw	dry weight
EAB	enhanced aerobic biodegradation
EBS	Exposure Barrier System
Ecology	Washington State Department of Ecology
EHO	East Harbor Operable Unit
EPA	US Environmental Protection Agency
ESD	Explanation of Significant Difference
ft	feet
FSP	Field Sampling Plan
GPS	Global Positioning System
HDR	HDR Engineering, Inc.
HPAH	high molecular weight polycyclic aromatic hydrocarbons
HSP	Health and Safety Plan
ISS	<i>In-situ</i> solidification/stabilization
LAET	lower apparent effects threshold
LOQ	limit of quantitation
LPAH	low molecular weight polycyclic aromatic hydrocarbons
LTM	long-term monitoring
m	meter
µg/kg	micrograms per kilogram
µg/kg-w	micrograms per kilogram – wet weight
MCA	Miller Creek Aerial Mapping, LLC
MCUL	minimum cleanup level
MLLW	mean lower low water
MNR	monitored natural recovery
MTCA	Model Toxics Control Act
NAPL	non-aqueous phase liquid
NTCRA	Non-Time Critical Removal Action



List of Acronyms

O&F	Operational and Functional
OC	organic carbon
OMMP	Operations, Maintenance, and Monitoring Plan
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PARCC	Precision, Accuracy, Representativeness, Comparability and Completeness
PCP	pentachlorophenol
PEF	potency equivalence factor
PRG	preliminary remediation goals
QAPP	Quality Assurance Project Plan
QAR	quality assurance review
RL	reporting limit
ROD	Record of Decision
RPF	relative potency factor
SCO	sediment cleanup objective
SEE	Science and Engineering for the Environment, LLC
SIM	select ion monitoring
SMS	Sediment Management Standards
SQS	Sediment Quality Standards
TerraSond	TerraSond, LTD
TEF	toxicity equivalency factor
TEQ	toxicity equivalence
TOC	total organic carbon
TPH	total petroleum hydrocarbon
USACE	United States Army Corps of Engineers
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WSDOT	Washington State Department of Transportation

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1 Introduction

This document presents the results of the Year 22 (i.e., 2016) monitoring at the Wyckoff/Eagle Harbor Superfund Site, East Harbor Operable Unit (EHOU), located on Bainbridge Island, Washington (Figure 1-1). The Record of Decision (ROD) for this Operable Unit (OU) is dated September 24, 1994 (EPA 1994).

The EHOU Operations, Maintenance, and Monitoring Plan (OMMP) was first developed in 1995 (EPA and USACE 1995) to support overall site management. The 1995 OMMP was implemented after completion of the first phases of remediation at the site (1994–1995) and was intended to guide monitoring related to remedy effectiveness and inform additional remediation needs. It was implicitly recognized in the 1995 OMMP that as site conditions warranted and/or further remedial actions were implemented, the OMMP would be amended to account for necessary changes in operations, monitoring, and management practices. The 2016 OMMP Addendum (USACE 2016), included as Appendix A, presents the fourth addendum to the 1995 OMMP. To date, the updates to the 1995 OMMP have included:

- 1999 OMMP Addendum (EPA and USACE 1999), which detailed the additional monitoring objectives and procedures for Year 5 monitoring
- 2002 OMMP Addendum (EPA and USACE 2002), which described changes to the long-term monitoring (LTM) program based upon post-1995 remedial activities at the site
- 2011 OMMP Addendum (HDR and SEE 2011)
- 2016 OMMP Addendum (USACE 2016)

The original Phase I cap (54 acres) was constructed in 1993 and 1994, was subsequently extended in several phases, and now covers more than 76 acres of intertidal and subtidal sediment. Monitoring studies conducted from 1994 through 2002 indicated that the 21.4-hectare sediment cap was largely functioning as intended through isolating the underlying contaminated sediments and providing suitable habitat for benthic organisms. Additional remediation occurred in West Beach where polycyclic aromatic hydrocarbon (PAH) concentrations were found to be elevated relative to the Washington State Sediment Management Standards (SMS). In the North Shoal and East Beach intertidal areas the progress of monitored natural recovery (MNR) was tracked, with a goal of achieving PAH levels below the SMS Minimum Cleanup Levels (MCUL)¹ within the 10-year timeframe set in the 1994 ROD. A summary of previous site activities is provided in Section 1-2 and in Table 1-1.

Physical monitoring results from the 2011 monitoring event showed substantial loss of the subtidal cap located within the ferry navigation lanes. Additional physical surveys

¹ The Washington State SMS have been updated since the 1994 ROD. Based on those updates, the Sediment Quality Standard (SQS) and MCUL are now referred to as the Sediment Cleanup Objective (SCO) and the Cleanup Screening Level (CSL), respectively (Washington Administrative Code 173-204). For the purposes of this 2016 Year 22 Monitoring Report, the terms SQS and MCUL and the associated levels reported in the 1994 ROD (Table 8) and/or the 2012 OMMP will be used.

were undertaken by the U.S. Environmental Protection Agency (EPA) through a contract with the Washington State Department of Natural Resources (WDNR) (see discussion in Section 1.3). That report provided additional data to aid in planning for cap repair in the Phase I scour areas and to support EPA's planned site maintenance activities in the area offshore of the former facility's historical West Dock (see Figures 1-2 and 1-3). The latter area, which includes sampling grids J9 and J10, is on the margins of sequential past capping efforts. These data were collectively used by EPA in planning for cap repair construction activities; repair of the cap occurred in early 2017.

The 2016 OMMP Addendum focused monitoring activities principally on the West Beach Exposure Barrier System (EBS), subtidal cap monitoring within grids J9 and J10, and on the North Shoal subtidal surface sediments. These data will be used to inform the Five-Year Review prepared in 2017, as well as data to support an Operational and Functional (O&F) determination.

The Year 22 monitoring did not include monitoring associated with the Phase I, Phase II, or Phase III cap, the North Shoal Intertidal area, and MNR at East Beach (as was included with the Year 17 monitoring activities). These areas are currently being considered for additional remedial actions, as documented in EPA's *Proposed Plan for Amending the Records of Decision for the Wyckoff/Eagle Harbor Superfund Site (Operable Units 1, 2, and 4)* (EPA 2016).

The U.S. Army Corps of Engineers (USACE) also gathered clams for chemical analysis of the tissue in association with Year 22 monitoring. The results of the USACE efforts are included in this monitoring report. The data gathered during Year 22 monitoring will supply information to EPA in support of the 2017 Five-Year Review.

1.1 Year 22 Monitoring Report Organization

Section 1.0 of this monitoring report provides background for the Year 22 monitoring program such as site chronology, recent activities, site terminology, and results of past monitoring activities. Section 2.0 identifies environmental data collection methods and procedures and reports any significant deviations from the Work Plan and Quality Assurance Project Plan (QAPP) (HDR, SEE, and MCA 2017). Section 3.0 reports the results of the monitoring efforts, and Section 4.0 discusses the results in relation to the monitoring approach described in the 2016 Addendum to the OMMP. The QAPP materials supporting implementation of the 2016 Addendum is provided in Appendix B.

1.2 Site History and Recent Site Activities

1.2.1 Site Chronology

A succession of companies treated wood and wood products from the early 1900s through 1988 at the Wyckoff site. Initially, treatment was accomplished by wrapping wood and poles with burlap and asphalt; however, by 1910 pressure treatment with creosote and bunker oil began. The Wyckoff treatment plant was one of the largest in the United States. Wood preservative and treatment operations included:

- The use and storage of creosote, pentachlorophenol (PCP), solvents, gasoline, antifreeze, fuel, waste oils, and lubricants



- Generation and management of process wastes
- Treatment and discharge of wastewaters
- Storage of treated wood and wood products

Little historical information exists about the waste management practices at the Wyckoff facility. Prior to its reconstruction in the 1920s, the facility was reported to have floated logs in and out of the lagoon that once existed at the Wyckoff facility. The practice of storing treated pilings and timber in the lagoon continued until the late 1940s. The lagoon was eventually filled and, beginning in the 1940s, treatment practices allowed chemical solutions to drain onto the ground from retorts. Subsequently, the post-retort chemicals seeped into the soil and groundwater. Wastewater was discharged into Eagle Harbor for an unknown number of years, and treated logs were transported to and from the facility at the former West Dock via a transfer table pit. Additional introduction of process and treatment-related products and wastes occurred during this period of facility operation and included releases from handling, drips, and spills. These practices continued until operations ceased in 1988.

A brief chronology of site events and activities that are pertinent to the East Harbor OU, the 1995 OMMP, and development of the 1999, 2002, 2011, and 2016 OMMP Addenda is provided in Table 1-1. The chronology is updated from the 2011 OMMP Addendum (HDR and SEE 2011). Additional relevant activities are discussed in further detail in the following sections.

1.2.2 Site Terminology

Throughout this document specific terms will be used to reference the study areas within the EHO. Figures 1-2 and 1-3 show the areas of the EHO that have been remediated along with the extent of individual removal actions or remedial activities. Below are the definitions of specific terminology for each action and study area for the EHO.

1994 Eagle Harbor Operable Units. The Wyckoff/Eagle Harbor Superfund site comprises four distinct OUs, including the East Harbor subtidal and intertidal sediments (OU 1); Wyckoff Facility soils (OU 2); West Harbor subtidal and intertidal sediments and upland sources (OU 3); and Wyckoff Facility groundwater (OU 4). Eagle Harbor OUs are shown in Figure 1-1.

1994 Phase I Subtidal Cap. The 1994 Phase I subtidal cap was placed in 1994-1995 as part of a Non-Time Critical Removal Action (NTCRA). This NTCRA consisted of placement of an approximately 1-meter (m) thick sediment cap over 53.9 acres (21.4 hectares) of subtidal sediments. Figure 1-2 depicts the extent of the 1994 Phase I sediment cap.

2000 Phase II Subtidal Cap. Figure 1-2 shows the 2000 Phase II subtidal cap, which was placed to augment the 1994 Phase I cap. The 2000 Phase II cap overlaps the Phase I cap at its southern boundary and covers shallow subtidal sediments that had not been previously capped in 1994. In the area where the 2000 Phase II cap overlaps the 1994 Phase I cap, materials were placed to cover surface sediments with PAH concentrations above the Sediment Quality Standards (SQS), as reported in the 1999 Year 5 monitoring results.

2001 Phase III Subtidal and Intertidal Cap. The 2001 Phase III cap extends shoreward from the 2000 Phase II cap. It overlaps both the 1994 Phase I and 2000 Phase II caps. It was placed over uncapped shallow subtidal sediments and intertidal sediments. Figure 1-2 shows the extent of the 2001 Phase III cap.

2017 Phase I Subtidal Cap Repair Area. The 2017 Phase I cap repair action is located at the northwest portion of the Phase 1 cap proximal to the Washington State Department of Transportation (WSDOT) ferry dock. Sediment within the repair area is subtidal, with depths ranging from -40 to -50 feet (ft) mean lower low water (MLLW). One foot of clean Snohomish River sand was placed over the 9.3 acre repair area. A 2-foot-thick rock layer was placed on top of the sand cover to armor 3.5 acres immediately proximal to the ferry lane. The cap repair area is presented in Figure 1-2.

West Beach. West Beach (formerly known as the Mitigation Beach) lies at the western edge of the Wyckoff property boundary and encompasses both the EBS and adjacent riparian habitats.² West Beach and the delineation of the EBS and the Intertidal Cap are shown in Figure 1-3. The West Beach, as it is now configured, includes the EBS, and was constructed in 2000 and 2001, when the areas above +17 ft MLLW were vegetated to provide riparian habitat around the Wyckoff facility.

Exposure Barrier System. Completed in 2008, the EBS covers approximately 5.1 acres of intertidal and shallow subtidal sediments on West Beach. The location of the EBS is shown in Figures 1-2 and 1-3. The EBS design consists of a porous geotextile placed on the original beach, a 1-foot thick layer of 3-inch cobbles placed on top of the geotextile (from approximately +14 ft to -5 ft MLLW), and a 0.66-m-thick (2-foot-thick) layer of fish habitat fill placed on top of the cobble layer. The subtidal cap extension involved the placement of a 1-m-thick (3-foot-thick) layer of sand and gravel covering the subtidal area (to a depth of -10 ft MLLW) immediately north of West Beach and extending up to the southern edge of the existing harbor cap.

Intertidal Cap. The Intertidal Cap is the extension of the 2001 Phase III subtidal cap shoreward, covering the intertidal surface sediments where PAH concentrations exceeded the SQS. Figures 1-2 and 1-3 depict this cap.

North Shoal Nearshore. The North Shoal Nearshore area consists of the intertidal area on the north shore of the former Wyckoff facility. It is bounded to the west by the Intertidal Cap and to the east by East Beach. Figure 1-3 shows the North Shoal Nearshore area.

North Shoal Subtidal. The North Shoal Subtidal area is offshore due north of the nearshore intertidal area, in waters deeper than -4 ft MLLW. The area is bounded to the west by the Phase I cap and to the north by the WSDOT ferry lane; its eastern edge is undefined (see Figure 1-2).

East Beach. East Beach consists of the intertidal area on the eastern side of the former Wyckoff facility. As depicted in Figure 1-3, it is bounded to the north by the North Shoal and extends south to the Wyckoff property boundary.

² Historically, the beach up to and including Pritchard Park has been termed “West Beach.” The 1994 ROD and subsequent EPA administrative documents define West Beach to be up to the western property line of the former Wyckoff facility. This report follows that convention, and defines sampling west of the administrative property line as “off West Beach” or “off-EBS,” as appropriate.



1.2.3 Highlights of Operable Unit 1 Remedial Activities

Completed upland and in-water remedial actions at the EHOU include:

- Placement of a subtidal sediment cap, completed in three phases between 1994 and 2002.
- Upland source control completed in February 2001 by installation of a sheet pile wall around the perimeter of the former process area.
- Construction of the West Beach (completed in 2002), including removal of 1,200 ft (366 linear m) of bulkhead; excavation of approximately 1,077,097 cubic feet (cf) (30,500 cubic meters) of upland sediments; and placement of 229,545 cf (6,500 cubic meters) of clean imported sand, creating approximately 2 acres (0.8 hectares) of intertidal beach habitat.
- Construction of the EBS in 2008 covering approximately 300 linear meters of West Beach and approximately 5.1 acres from the southern edge of the existing subtidal cap.
- Phase I cap repair area (early 2017) involved placement of approximately 1-foot of clean Snohomish River sand over 9.3 acres of previously capped subtidal areas, and placing a 2-foot thick rock layer on top of a portion (3.5 acres) of the cap repair area as armor (see Figure 1-2).

1.2.4 Proposed Additional Remedial Actions

EPA (2016) released a Proposed Plan for additional cleanup activities for the upland and in-water areas at the Wyckoff Facility. The preferred alternatives for the upland and in-water (nearshore) are presented in the Proposed Plan, and are briefly described in the text that follows.

For the upland unit, EPA proposed the following:

- *In-situ* solidification/stabilization (ISS) of the most heavily contaminated soils in the center of the former process area at Wyckoff. Reagents, including cement, would be mixed into approximately 144,000 cubic yards (cy) of soil.
- Recovery of non-aqueous phase liquid (NAPL) using new extraction wells north of the ISS footprint where the thickness of the NAPL suggests it would be amenable to recovery. Recovered NAPL would be transported offsite for incineration in a hazardous waste incinerator.
- Enhanced aerobic biodegradation (EAB) to treat contamination along the inside of the upland perimeter barrier wall. With EAB, air is injected into the groundwater to promote the breakdown of contaminants by naturally occurring bacteria.
- A new concrete wall would be built around the perimeter of the upland portion and a final cap would be installed over the soil treatment portion.

For the nearshore, EPA's preferred alternative is partial excavation with capping. This plan includes:

- Actively remediating areas along the North Shoal and East Beach that were identified to have NAPL in the top 2 ft below mudline. The active remedial area in the East

Beach is approximately 1.6 acres. Additional characterization will be conducted in the North Shoal to refine the target remedial areas.

- The target areas will be remediated by the removal of the top 30 inches of sediment and replacing the material with a permeable reactive cap. The cap would consist of three layers: (1) a 4- to 6-inch-thick layer of reactive materials at the bottom of the excavated area, (2) a demarcation layer (e.g., coarse gravel or cobble), and (3) clean sand (~2 ft) above the demarcation layer installed to be flush with the surrounding sediment surface.
- For the remainder of East Beach (9.2 acres), MNR will continue as the remedial alternative.

Long term operations, monitoring, and maintenance are included for these alternatives in the Proposed Plan. EPA and the USACE will develop a new long-term OMMP that will include the Phase I, II, and III caps, the EBS, the 2017 Phase 1 cap repair, and the work described in the Proposed Plan.

1.3 Results of Previous Monitoring Events (1994 – 2011)

This section reviews the results of the offshore and intertidal monitoring events conducted between 1994 (Year 0) through 2011 (Year 17). Monitoring of these combined remedies has historically been designed to assess the following:

- The subtidal sediment caps: physical stability, effectiveness in isolating contaminants, and potential for recontamination
- The intertidal areas: physical stability, effectiveness in isolating contaminants, natural recovery, and habitat use
- The EBS: physical stability, effectiveness in isolating contaminants, and habitat function.

1.3.1 Subtidal Sediment Monitoring

To date, five OMMP monitoring events have been completed on the 1994 Phase I cap (Figure 1-2). An additional evaluation of the Phase I cap's condition was conducted in 2013 (Appendix C). Only two monitoring events have been conducted to date on the Phase II and Phase III caps (2002 and 2011).

Physical Stability

The 2002–2003 monitoring report (Integral and USACE 2004a) concluded that the Phase I, II, and III caps were physically stable. Physical stability was confirmed by both a bathymetric survey and cap thickness measurements determined from through-cap coring. The 2002-2003 bathymetric survey did not extend into the northern portion of the Phase I cap because, as noted in the 2002 OMMP Addendum, past monitoring indicated that the northern portion of the 1994 sediment cap was stable and functioning as intended.

The 2011 results monitoring report concluded that the northern and southern sections of the subtidal cap are physically stable, and generally have remained at the target



thickness. This conclusion was based on the bathymetric profiles, cap thickness measurements from the sediment cores, and results of the sediment mobility analysis modeling. In contrast, a limited area at the northwest perimeter of the Phase I cap immediately proximal to the ferry lane (grids E3 through I3, and G4 through J4) were demonstrably not physically stable and did not have cap material at the target remedial goal (≥ 2 ft). The bathymetric profiles clearly indicated areas of erosion around the ferry lanes. Sediment cores and surface grabs supported this conclusion by the complete absence of capping material at grids H4 and G4 and less than 1 ft of material at J4 (HDR and SEE 2012).

Additional physical surveys were undertaken in 2013 (Appendix C). Cap thickness measurements were made using 46 videoprobes and 8 vibracores, principally in the northern area of the Phase I cap near the ferry lane, and in the area of grids J9 and J10. Using those data, combined with the 2011 coring data collected in the same vicinity, it was confirmed that the Phase I cap along the ferry lane had been substantively eroded (HDR and SEE 2012).

Chemical Isolation

With the exceptions discussed below, the subtidal cap has been shown to be effectively isolating the underlying contaminated sediments. Chemical isolation had been evaluated based upon results of chemical analyses of the subtidal through-cap cores relative to the SMS in 2002 and 2011. In the monitoring events prior to 2002, the northern portion of the Phase I cap had been shown to be stable and functioning as intended; no evidence of vertical migration of underlying contaminants upward into the sediment cap was identified in the northern areas of the Phase I cap.

The Year 8 (2002) monitoring study cored nine stations located on the southern portion of the Phase I cap and on the Phase II/III caps. Through-cap cores collected in 2002 provided evidence that the caps are effective in physically isolating the underlying contaminated native sediments, with four exceptions: H9, I9, I10, and J10 were found to have elevated PAH concentrations that exceeded criteria in the primary gradient; the relative location of the primary gradient is illustrated in Figure 1-4.³ When the results from H9, I9, and I10 were more appropriately compared to the Lower Apparent Effects Threshold (LAET) (because total organic carbon [TOC] concentrations in these samples were less than 0.1%), no exceedances were noted.

The 2011 survey showed that the subtidal cap is effectively isolating the underlying contaminated sediments, with the exception of the area within the ferry lane scour zone. Chemical isolation of underlying contaminants was evidenced by the results of 20 subtidal surface sediment samples and 14 through-cap core samples. Only 3 of the 20 subtidal surface sediment samples were found to exceed the SQS (G4, H4, and I4) and these were located within the ferry lane scour zone. All other areas of the subtidal cap met the surface sediment target remedial goals (i.e., concentrations below the SQS standards for PAHs, dibenzofuran, and PCP). All three of the failed subtidal surface

³ The primary gradient is defined as that interval of a core sample that is 15-30 cm above the cap/native sediment interface or 15-30 cm above the Phase II and III cap/Phase I cap interface if Phase II/III cap material is present. The primary gradient is measured as an indication of potential migration of PAHs into the cap (Integral and USACE 2004a); see Figure 1-4.

sediment samples had no or little surface cap material and showed evidence of NAPL in the grab samples.

The only primary gradient core sample that exceeded the SQS was the sample taken within grid G8. All other cores had PAH concentrations below the SQS. The shallow gradient sample subsequently analyzed at G8 did not show an exceedance of the SQS for any parameter.

Chemical isolation was further confirmed by the finding that surface sediments on the subtidal cap in the biologically-active zone remain clean relative to the SMS. The exception to that were those stations within the ferry lane scour zone where no cap material was evident and/or NAPL was visible in the grab samples. Further evidence of the overall subtidal cap performance was made in 2011 by comparing the changes in concentrations of low-molecular weight PAHs (LPAHs) and high-molecular weight PAHs (HPAHs) in the surface sediment over time. For the 11 stations for which comparable time data were available, the dry weight concentrations have generally been decreasing over time.

Grids J9 and J10

Grids J9 and J10 required focused sampling during the Year 8 and Year 17 monitoring events. Grids J9 and J10 are located proximal to the Phase I/II/III cap and the North Shoal Nearshore (Figure 1-2). This area includes the former historical West Dock area, and is at the margins of all three cap areas.

Sampling in Year 8 identified florets of PAH sheen in two of the three grab samples collected within these grids, as well as a PAH odor. The surface sediment samples from J9 in Year 8 identified PAH concentrations exceeding the SQS, the MCUL for dibenz(a,h)anthracene, and had the greatest TPH/DRO concentrations (23,300 micrograms per kilogram [$\mu\text{g/kg}$]) measured from subtidal cap surface sediments. Two cores collected at J10 showed hydrocarbon staining in the surface and subsurface sediments, with PAH concentrations exceeding the LAET.

Focused studies in Year 17 included three discrete surface sediment grab samples each in J9 and J10 (total of six discrete samples). Analytical results for these six total discrete surface grab samples were below the SQS criteria.

Also during Year 17 monitoring, four cores were collected in J9, while three cores were collected in J10. Within J9, three of the four coring locations exhibited complete lack of cover material, while the fourth core had only 1.2 ft of Phase II/III capping material. Two of the J9 cores were analyzed for the primary and shallow gradient (see Figure 1-4). In location J9b, both the primary and shallow gradient samples had exceedances of the SQS for all measured PAHs and some semivolatile compounds. As noted above, the surface sediment grab sample for J9b did not exceed the SQS. For the second sample, J9c, no exceedances were identified for any SQS chemicals of concern (COCs) in the primary gradient sample.

Within J10, two of the cores had cover thickness of 2.8 ft and 4.4 ft, while the third core had only 1.3 ft of cover material. For the three cores collected in J10, no exceedances were identified for any COC in the primary gradient sample.

The 2014 cap condition report (Appendix C) did include video probe cover thickness measures within Grids J9 and J10, and confirmed the Year 17 monitoring conclusions



that additional material placement was needed, principally in J9. The volume of material estimated to isolate the bottom sediments ranged from approximately 2,500 cy (to cover the area to 1.5 ft of depth) to 6,500 cy (to cover that same area to 3.0 ft of depth).

1.3.2 Intertidal Sediment Monitoring

Four adjacent intertidal areas are defined around the perimeter of the Wyckoff site as shown in Figure 1-3: East Beach, North Shoal, the Intertidal Cap, and the EBS. The areas are artificially separated for monitoring purposes but represent continuous intertidal habitat surrounding the site. Results of monitoring based on the objectives described in the 2012 Monitoring Report for these four areas are described below.

East Beach

The purpose of East Beach monitoring program has been to determine whether contaminant concentrations have decreased over time and to evaluate whether the rate of natural recovery is within the 10-year time frame established in the ROD.

In 2002, PAH compounds were detected in all surface sediment samples collected from East Beach. The highest concentrations were found at the nearshore stations closest to the seeps, which had numerous exceedances of the SMS criteria (Integral and USACE 2004a). Concentrations of PAHs decreased with distance away from the seeps. The five seep samples also detected concentrations of total petroleum hydrocarbons (TPH) and diesel range organics (DRO), with the greatest concentration observed at the northern seep samples. TPH and DRO concentrations rapidly decreased with distance away from the seeps.

The 2011 East Beach monitoring indicated that overall seeps appear to have decreased over time, but that some seeps persisted, particularly at the north end of East Beach. This was subsequently confirmed during the field investigations for EPA's Focused Feasibility Study (CH2M 2013). In the 2011 sampling, PAHs were detected in all surface sediment sampling locations, but only exceeded the human health and/or ecological criteria at two locations at the northernmost stations (M10-e4 and N10-a4 in the 2012 report). The subsurface sediments at East Beach still contain substantive residual hydrocarbon in the northern and central transects (M10-e4, N10-a4, N11-a2 and N11-b5). NAPL-bearing strata were observed in the cores, and elevated PAH concentrations were measured within 1 to 3 ft below mud surface (bms).

The 2012 report concluded that no substantial difference existed in the extent and concentrations of subsurface PAHs between 2003 and 2011 in core logs or analytical results. Given those conditions, the East Beach has not met the ROD-defined natural recovery cleanup goals in 10 years.

North Shoal

The North Shoal was reported to be relatively stable in 2002. While mobile NAPL is known to exist on the North Shoal at depths deeper than -15 ft MLLW (USACE 1999), visible seeps have not been observed in the majority of this area. One seep has been periodically visible on the east side of the North Shoal and is likely related to the visible seeps on the north end of East Beach.

The Year 8 monitoring report (Integral and USACE 2004a) indicated that PAHs were detected in all three surface composite samples collected from the North Shoal. Surface sediments at station K9-d3⁴ exceeded criteria for several PAH compounds, including total LPAH and total HPAH. TPH and DRO were also measured at a concentration of 234 mg/kg at K9-d3. The two remaining stations (stations L9-b4 and K9-d3 in that report) had total HPAH concentrations that exceeded the supplemental human health criterion of 1,200 µg/kg total HPAH.

Findings in the 2012 report were consistent with those in the 2004 report. Seeps were not observed during either monitoring program. Evidence of hydrocarbons (i.e., sheening and/or odor) was reported in the 2012 collection of surface grabs at the westernmost sample locations (K9-d3 and K9-b4); exceedances of the human health criteria and/or ecological criteria were reported at these same locations.

Intertidal Cap

The Phase III Intertidal Cap area was created to contain contaminated subtidal sediments and to provide an intertidal habitat connection between the North Shoal and West Beach areas. The Intertidal Cap was monitored for surface chemistry in three locations during the Year 8 monitoring event. PAH concentrations did not exceed either the TOC-normalized SQS criteria or the dry-weight LAET criteria. The results of the 2004 beach elevation and bathymetric surveys indicated that the Intertidal Cap area appeared depositional and physically stable. The visual survey of the Intertidal Cap indicated that it was providing habitat for forage fish and benthic infauna.

The Year 17 monitoring (i.e., 2011) concluded that the Phase III Intertidal Cap is physically stable and that the analytical measures of the cover material were below both the SQS and the ROD-defined human health risk criteria. Physical stability was based upon a comparison of the 2005 and 2011 bathymetry which showed that the area is either stable or depositional over that time frame. No cores or cover thickness measurements were made in the Intertidal Cap; whether the cap remained at the design thickness could not be assessed.

Exposure Barrier System

EPA completed construction of the EBS in 2008 to isolate visibly contaminated sediments within the first four feet of the surface. The Year 17 assessments were the first post-construction monitoring event on the EBS. The Year 17 monitoring suggested that the EBS may not have achieved physical stability, particularly in the lower intertidal areas. Elevation surveys showed that both erosion and accretion have occurred at the EBS between construction in 2008 and the surveys conducted in 2011. Within the lower intertidal areas there were apparent losses of between 1 and 2 ft of cap elevation, while the high intertidal areas gained up to 2 ft of new material. The Year 17 monitoring report

⁴ This Year 22, 2017 Monitoring Report corrects an error from the 2004 and 2012 monitoring reports. The Year 8, 2004 Monitoring Report incorrectly identified station M9-a3 as having high concentrations of PAHs that exceeded the MCUL and/or the SQS. That error was carried through into the Year 17, 2011 Monitoring Report. Table 3-5 in the 2004 report shows that station K9-d3 exceeded the SQS and MCUL for several PAHs, while PAH levels for M9-a3 were either non-detect or J-flagged at low concentration levels well below the corresponding SQS.



concluded that approximately 5,005 cy have been lost from the EBS since placement in 2008.

While apparent losses of between 1 and 2 ft were identified using bathymetry in the lower intertidal zone, direct thickness measures made in the field in 2011 showed that all of the low intertidal sampled stations had cover thickness measurements greater than the target 1 ft of cover thickness. Four stations with less than 1 ft of cover thickness were identified in the high intertidal area at the upper edge of the fill area. All chemical analyses of the cover material were below both the SQS/MCUL and the ROD-defined human health risk criteria.

1.3.3 Biological Monitoring

The 2002 monitoring (Year 8) report indicated that the upland habitat planting of the West Beach (i.e., the EBS) area had been in the process of being successfully established (Integral and USACE 2004a). Resident and migrant birds were observed, as well as transient use by mammals. Invertebrate fauna were present to serve as food sources for higher trophic species. Sand lance eggs were collected in the intertidal area of the West Beach, but smelt eggs were not found. The 2002 report also noted use of the Intertidal Cap by demersal fish, benthic infauna, and sand lance.

The Year 8 monitoring report also cited a National Marine Fisheries Service study of the impacts of PAH compounds on English sole. The study showed declining trends in biomarker exposure to PAHs. Risk reduction was most obvious three years post-capping and had stayed low through 2002.

Year 17 biological monitoring (2011) included surveys of birds, mammals, invertebrates, and macroalgae; a forage fish survey; and clam tissue measurements for PAHs. Twenty-eight species of birds were observed using the riparian or intertidal areas at the site during the fall and spring surveys in 2011 and 2012. Evidence of use by river otters was also observed. The results of the survey of invertebrates provide qualitative evidence that limited fauna and flora have colonized the Intertidal Cap and continue to inhabit the East Beach and North Shoal. To a much lesser degree, fauna have colonized the EBS after its 2008 construction. The forage fish spawn survey conducted on the EBS and Intertidal Cap during the 2011 and 2012 surveys determined that the area had been utilized by spawning sand lance and to a lesser degree surf smelt.

1.3.4 Clam Tissue Monitoring

The USACE conducted the clam collection and tissue monitoring in 2003 and 2011. The 2004 clam tissue results (Integral and USACE 2004b) reported PAH analysis results from geoduck (*Panopea generosa*), horse clams (*Tresus capax*), and littleneck clams (*Leukoma staminea*). A post-hoc review of the photographs from the 2004 collection done prior to the collections for the Year 17 monitoring indicated that the clams identified as geoduck clams (collected at North Shoal in 2004) were actually horse clams (*T. capax*), and the clams identified as horse clams collected at East Beach are most likely butter clams (*Saxidomus gigantea*). Previously collected littleneck clams were correctly identified. Thus, the clam tissue analyzed during these two studies (i.e., 2003 and 2011), once reidentified, included horse clams, butter clams, and littleneck clams.

Data results of the clam tissue collected in 2003 found that PAHs in clam tissue were generally undetected, or were reported at levels below the quantitation limit of $\mu\text{g/kg-wet weight}$ ($\mu\text{g/kg-w}$). Phenanthrene, fluoranthene, and pyrene were detected in all samples but the concentrations were reported as estimates below the quantitation limit (Integral and USACE 2004b). The quantitation limit for the 2003 clam tissue PAH analysis was $120 \mu\text{g/kg-w}$. The reporting limit (RL) for the 2012 OMMP Report clam tissue PAH analysis was $0.93 \mu\text{g/kg-w}$. Therefore, comparison of the PAH tissue concentrations between the 2003 and 2011 sampling events was not possible.

The Year 17 monitoring reported that the sum of PAHs (where non-detect values were included at the RL) ranged from a high of $86.41 \mu\text{g/kg-w}$ at station North Shoal 2 to a low of $38.31 \mu\text{g/kg-w}$ at station East Beach 1. Chemicals with the highest values were anthracene and pyrene at East Beach 1, and phenanthrene and pyrene at North Shoal 2. Values at the North Shoal stations were greater (average $\sim 73 \mu\text{g/kg-w}$) than either the East Beach (average $\sim 52 \mu\text{g/kg-w}$) or Intertidal stations (average $\sim 56 \mu\text{g/kg-w}$). Lipid content ranged from a high of 0.71 percent at Intertidal Cap 3 to a low of 0.40 percent at East Beach 3. Lipid normalized values ranged from 16.3 mg/kg-w at North Shoal 2 to a low of 7.09 mg/kg-w at East Beach 1.

Total carcinogenic PAH (cPAH) toxicity equivalence (TEQ)⁵ were calculated for the Year 17 monitoring results; one-half the reporting limit was used to calculate the TEQ values for non-detected concentrations (at the RL) included in the summation ($0.5 \times \text{RL}$). Total cPAH TEQ concentrations ranged from a low of $2.98 \mu\text{g/kg-w TEQ}$ at East Beach 1 to a high of $5.64 \mu\text{g/kg-w TEQ}$ at North Shoal 1. The chemical with the highest TEQ concentrations was benzo[g,h,i]perylene at all stations. All the North Shoal stations had higher values (all TEQs greater than $4.0 \mu\text{g/kg-w}$) than either East Beach or the Intertidal stations (generally around a TEQ of $3.1 \mu\text{g/kg-w}$). As stated in the Year 17 monitoring report, *“The TEQs from this sampling can be used to facilitate a risk assessment at a later date. Data do not support a risk calculation at this time.”*

1.4 Purpose and Approach to Year 22 Monitoring

Specific elements and objectives of Year 22 (i.e., 2016) monitoring are summarized in Table 1-2 and the text that follows.

- *EBS and Off-EBS Sediment Core Collection and Monitoring* – Monitoring at the EBS and off the EBS included elevation surveys, visual seep surveys, a physical assessment of cover thickness (where appropriate), and sediment chemistry. A total of six locations on and off the EBS were sampled for surface sediments (0–2 ft) and analyzed for PAH, PCP, and conventional parameters.
- *Focused Sampling at Grids J9 and J10* – Surface samples within Grids J9 and J10 were collected, composited, and analyzed for PAHs, PCP, mercury, and

⁵ For this report, the terms toxicity equivalency factors (TEFs) and toxicity equivalence (TEQ) will be used interchangeably with the terms relative potency factors (RPF) and benzo(a)pyrene equivalence (B(a)P EQ), respectively. TEFs and TEQs were used in the 2012 OMMP Report, in EPA's Proposed Plan for OU1 (EPA 2016), and are the terms used by Washington State under MTCA (Ecology 2015). EPA's guidance (1993, 2010) for calculating cPAH equivalences uses RPF and expresses the sum as a benzo(a)pyrene TEQ. The Year 17 monitoring used the MTCA values to evaluate cPAH exposure for intertidal sediments, and the 1993 cPAH RPF for clam tissue. For this Year 22 Monitoring Report, results in intertidal sediments and clam tissues will be calculated using both the MTCA TEFs and EPA 1993 RPFs.



conventional parameters. Within each grid, three surface samples were collected and composited into one sample for analysis.

- *North Shoal Subtidal Area Surface Sediment Collection* – Surface sediments (0–10 centimeters [cm]) were collected at three locations from each of five subtidal grids (J7, K7, J8, K8, and L8). Those three discrete grabs per grid were composited into a single sample, and analyzed for PAH, PCP, mercury, and conventional parameters to identify if surface sediments along the North Shoal have PAH concentrations that exceed the SMS (i.e., SQS/MCUL).
- *North Shoal Subtidal Area Subsurface Sediment Collection* – Sediment cores were collected from one location within each of the same five subtidal grids sampled for surface chemistry. Vibracore samples were collected at a minimum depth of 2 ft bms, photographed, logged for lithology, and checked for the presence of NAPL.
- *Clam Tissue Collections* – Clams were collected from the intertidal areas from the North Shoal, West Beach/EBS, the Phase III cap, and East Beach. Collections and analyses were conducted by the USACE in 2014 and in 2016. Clam tissues were analyzed for PAH and lipids content to provide information of biological uptake of PAH, and used to assess potential risk. The clam tissue work plans, QAPP, and data reports are included in Appendix D.

1.4.1 EBS

Monitoring tools employed during the Year 22 intertidal monitoring included:

- **Precision Navigation.** Integrated navigation for all monitoring was provided with a positional accuracy of 2 m.
- **Aerial Elevation Survey.** Aerial measurements of beach elevations were taken to evaluate beach stability at the EBS. Accuracy and precision of the aerial elevation surveys are discussed in the elevation survey technical memorandum in Appendix I.
- **Bathymetry.** Bathymetric soundings were taken in the subtidal area of the EBS to be used in conjunction with the aerial elevation surveys to assess whether the EBS cover thickness has changed by comparison with previous surveys. Accuracy and precision of the bathymetric surveys are discussed in the elevation survey technical memorandum in Appendix I.
- **Surface Sediment Core Samples.** Core samples were collected in the top 2 ft of the EBS (and in two off-EBS locations to the west) and analyzed for PAHs, PCP, and grain size to evaluate the chemical and physical character of the EBS and whether chemical isolation has been maintained.
- **Clam Tissue Analyses.** Clams were collected from West Beach on the EBS. The collected tissues were analyzed to determine body burden of PAHs and to compare to standards for human health.

1.4.2 Subtidal Cap

Monitoring tools employed during the Year 22 subtidal cap monitoring program included:

- **Precision Navigation.** Integrated navigation for all monitoring was provided with a positional accuracy of 2 m.
- **On-cap Surface Sediment Grab Samples at J9 and J10.** Surface sediment grab samples were collected from within grids J9 and J10. These stations were formerly identified as having elevated PAH concentrations. The 2017 focus in the J9 and J10 area is intended to provide additional information for future remedial planning. These samples were analyzed for grain size, TOC, total solids, PAHs, PCP, and mercury.

1.4.3 North Shoal Subtidal Area

- **Precision Navigation.** Integrated navigation for all monitoring was provided with a positional accuracy of 2 m.
- **Surface Subtidal Sediment Grab Samples.** Surface sediments (0–10 cm) were collected at three locations from each of five subtidal grids (J7, K7, J8, K8, and L8). Those three discrete grabs were composited into a single sample, and analyzed for PAH, PCP, mercury, and conventional parameters.
- **Subtidal Sediment Cores.** Cores were collected from one location within each of the same five subtidal grids sampled for surface chemistry. Vibracore samples were collected at a minimum depth of 2 ft bms.

1.4.4 East Beach, North Shoal, and Intertidal Cap

Monitoring tools employed during the Year 22 intertidal monitoring included:

- **Precision Navigation.** Integrated navigation for all monitoring was provided with a positional accuracy of 2 m.
- **Clam Tissue Analysis.** Clams were collected from East Beach, North Shoal, and the Intertidal Cap. Clam tissue was analyzed to determine body burden of PAHs and compared to standards for human health.

Table 1-1. Chronology

Event/Activity	Date
The Wyckoff/Eagle Harbor site was added to the National Priority List (NPL)	1987
Completion of the Remedial Investigation (RI)	1989
Completion of the Feasibility Study (FS) for Eagle Harbor	1991
Removal Action – Placement of sand cap over 21.4 hectares of contaminated sediments	1993-1994
Construction monitoring of removal action	1993-1994
EPA completed ROD for the East Harbor OU, which included the following elements: (1) monitor and maintain the existing sediment cap, additional capping in remaining subtidal areas of concern; (2) monitor success of natural recovery in intertidal areas; (3) enhance existing institutional controls to reduce public exposure to contaminated fish and shellfish; (4) demolish in-water structures	1994
Baseline, Year 0 monitoring of subtidal cap	1994
Year 1 monitoring of subtidal cap	1995
Year 3 monitoring of subtidal cap	1997
Removal of in-water structures (e.g., piers and pilings)	1998-1999
1999 OMMP Addendum	1999
Year 5 monitoring of subtidal cap	1999
Installation of sheet pile wall around upland site	1999-2001
Intertidal investigation around the Wyckoff facility	1999-2002
Placement of Phase II subtidal cap	2000-2001
Placement of Phase III subtidal nearshore and intertidal cap	2001-2002
EPA created habitat Mitigation Beach at West Beach and placed Phase III subtidal nearshore and intertidal cap	2001-2002
2002 OMMP Addendum	2002
Year 8 monitoring of subtidal cap, intertidal cap, Mitigation Beach, and East Beach natural recovery	2002
First 5-Year Review	2002
Surface sediment samples in the visibly-contaminated areas of the West Beach Mitigation Beach	2005
West Beach intertidal sediment investigations	2005-2006
Second 5-Year Review (EPA 2007a)	2007
Explanation of Significant Difference (ESD) for the West Beach Exposure Barrier System (EBS)	2007
Construction of the West Beach EBS	2007-2008
2011 OMMP Addendum	2011
Year 17 monitoring of subtidal cap, intertidal cap, EBS, East Beach, and North Shoal natural recovery	2011
Additional East Beach and North Shoal investigations	2012
Third Five-Year Review	2012
Additional subtidal cap investigations (WDNR-directed)	2014
Clam tissue collection and analyses	2014
Proposed Plan for East Harbor and Upland OUs completed	2016
2016 OMMP Addendum	2016/2017
Clam tissue collection and analyses	2017

Notes:

EBS - Exposure Barrier System

EPA - Environmental Protection Agency

ESD - Explanation of Significant Difference

FS - Feasibility Study

NPL - National Priority List

OMMP - Operation, Maintenance, and Monitoring Plan

OU - Operable Unit

RI - Remedial Investigation

ROD - Record of Decision

WDNR - Washington State Department of Natural Resources

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Table 1-2. Area and Monitoring Objectives

EHOU Objective A1		Area Objective	Monitoring Objective	Associated Field and Analytical Actions (for Discussion)	Evaluation Process and Criteria
O&F	5 YR				
Subtidal Cap (J9, J10)					
X	X	Determine if the cap meets cleanup goals as defined in the ROD.	Evaluate chemical isolation in surface capped sediments and determine the presence or absence of non-aqueous phase liquid (NAPL) in subsurface sediments	Surface Sediment Samples. Surface sediment (0-10 cm) samples from grids J9 and J10. Three grab samples from each grid will be collected and composited into one analysis for polycyclic aromatic hydrocarbons (PAHs), pentachlorophenol (PCP), mercury, total organic carbon (TOC), and grain size. Sediment from each grab sample will be reserved and archived for future analysis, if necessary.	Compare results to Washington State Sediment Management Standards (SMS) Minimum Cleanup Level (MCUL) or second Lowest Apparent Effects Threshold (2LAET).
North Shoal Subtidal Area (Grid Cells J7, J8, K7, K8, L8)					
	X	Characterization of the subtidal area of the North Shoal.	Evaluate chemical concentrations in subtidal surface sediments and determine the presence or absence of NAPL in subsurface sediments.	Surface Sediment Samples. Surface sediment (0-10 cm) samples from grid cells J7, J8, K7, K8, and L8. Three grab samples per grid will be collected and composited into one analysis for PAHs, PCP, mercury, TOC, and grain size. Sediment from each grab sample will be reserved and archived for future analysis, if necessary.	Compare results of surface samples to Washington State SMS MCUL or 2LAET.
	X	Visual characterization of subsurface sediment.	Determine the presence or absence of NAPL in subsurface sediments.	Subsurface Sediment Cores. A single subsurface sediment core (6-foot length) will be collected from grid cells J7, J8, K7, K8, and L8. Cores will be evaluated for the presence or absence of NAPL, sandy cap material, and other debris (e.g. wood, shells, etc.).	Visually evaluate subsurface cores for the presence or absence of NAPL, sandy cap material, and debris.
West Beach/EBS					
	X	Assess contaminant concentrations in surface sediments to evaluate potential human exposures.	Evaluate chemical concentrations in beach sediments.	West Beach Surface/Subsurface Cores. Surface/subsurface sediment cores (2-ft length) from the West Beach (includes the EBS and the area west of West Beach). Four sample stations based on the OMMP grid system were selected, plus two discretionary core locations (to be field determined). Three cores per sampling location will be collected, then composited into a single sample for analysis. Samples will be analyzed for PAHs, PCP, TOC, and grain size.	Compare results to SMS, Model Toxics Control Act (MTCA) Method B, and Preliminary Remediation Goals (PRGs).
X	X	Assess the effectiveness of placed cap at the EBS in isolating contaminants.	Evaluate physical stability of the West Beach and the EBS.	West Beach Survey Program. Surveys will be conducted in the West Beach area (EBS and west of West Beach) to evaluate current physical conduction of cap (including topographics, field, and bathymetric surveys, along with Airborne LIDAR and area imagery acquisition). EBS Habitat Mix and Sand Cap Direct Measurement. Measure the thickness of the EBS in eighteen locations.	Assess physical stability and trends at West Beach and the EBS.
X	X	Determine if intertidal areas provide functioning habitat.	Evaluate whether the placed remedies provide functioning habitat – natural recovery, and whether shellfish are safe for human consumption.	Clam Tissue Samples. USACE will collect clam samples from all intertidal areas.[1]	Track trends with previous tissue data and compare clam tissue chemistry results to standards for human health. [The proposed target tissue concentration for cPAHs is 0.12 µg/kg (benzo[a]pyrene) TEQ][2].

Notes:

2LAET - Second Lowest Apparent Effects Threshold
µg/kg - micrograms per kilograms
cm - centimeters
EBS - Exposure Barrier System
EHOU - Eagle Harbor Operable Unit
ft - feet
LIDAR - Light Detection and Ranging

MCUL - minimum cleanup level
MTCA - Model Toxics Control Act
NAPL - non-aqueous phase liquid
O&F - operational and functional determination
OMMP - Operation, Maintenance, and Monitoring Plan
PAH - polycyclic aromatic hydrocarbon
PCP - pentachlorophenol

PRG - Preliminary Remediation Goals
ROD - Record of Decision
SMS - Washington State Sediment Management Standards
TEQ - toxicity equivalence
TOC - total organic carbon
USACE - United States Army Corps of Engineers

Other Notes:



5 YR denotes objective for the upcoming 5 year review

[1] Clam sampling was completed by USACE on July 5-6, 2016, prior to finalization of the 2016 OMMP Addendum.

[2] This is the selected target tissue concentration in the 2016 Proposed Plan for the East Harbor and Uplands OUs. Final target concentrations will not be determined until the ROD Amendment is issued.

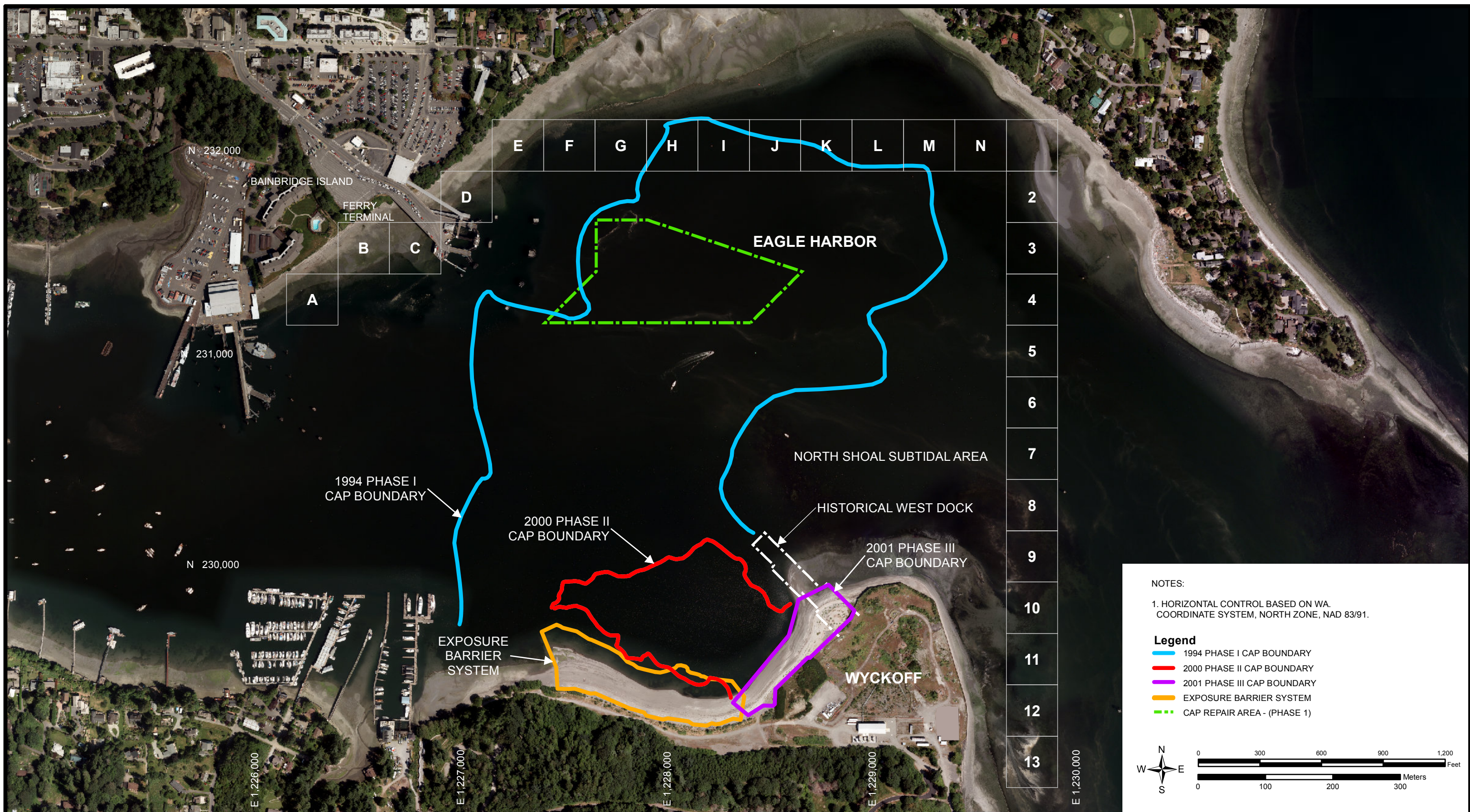
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Project Name		Figure Name		
 		2016 OMMP Implementation East Harbor Operable Unit Wyckoff/Eagle Harbor Superfund Site	Aerial Photograph of the East Harbor Operable Unit, Wyckoff/Eagle Harbor Facility	Figure 1-1

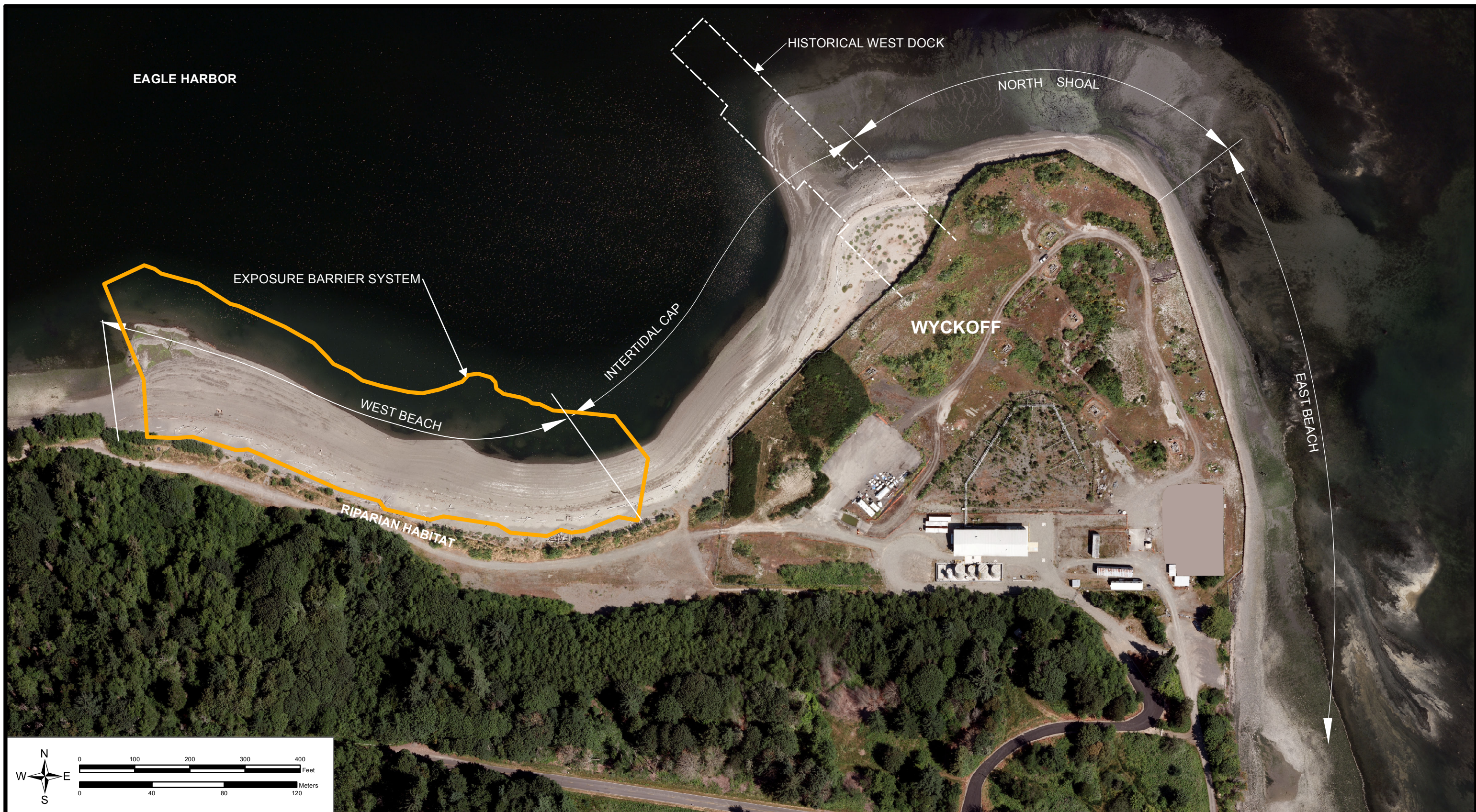


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Project Name

Figure Name



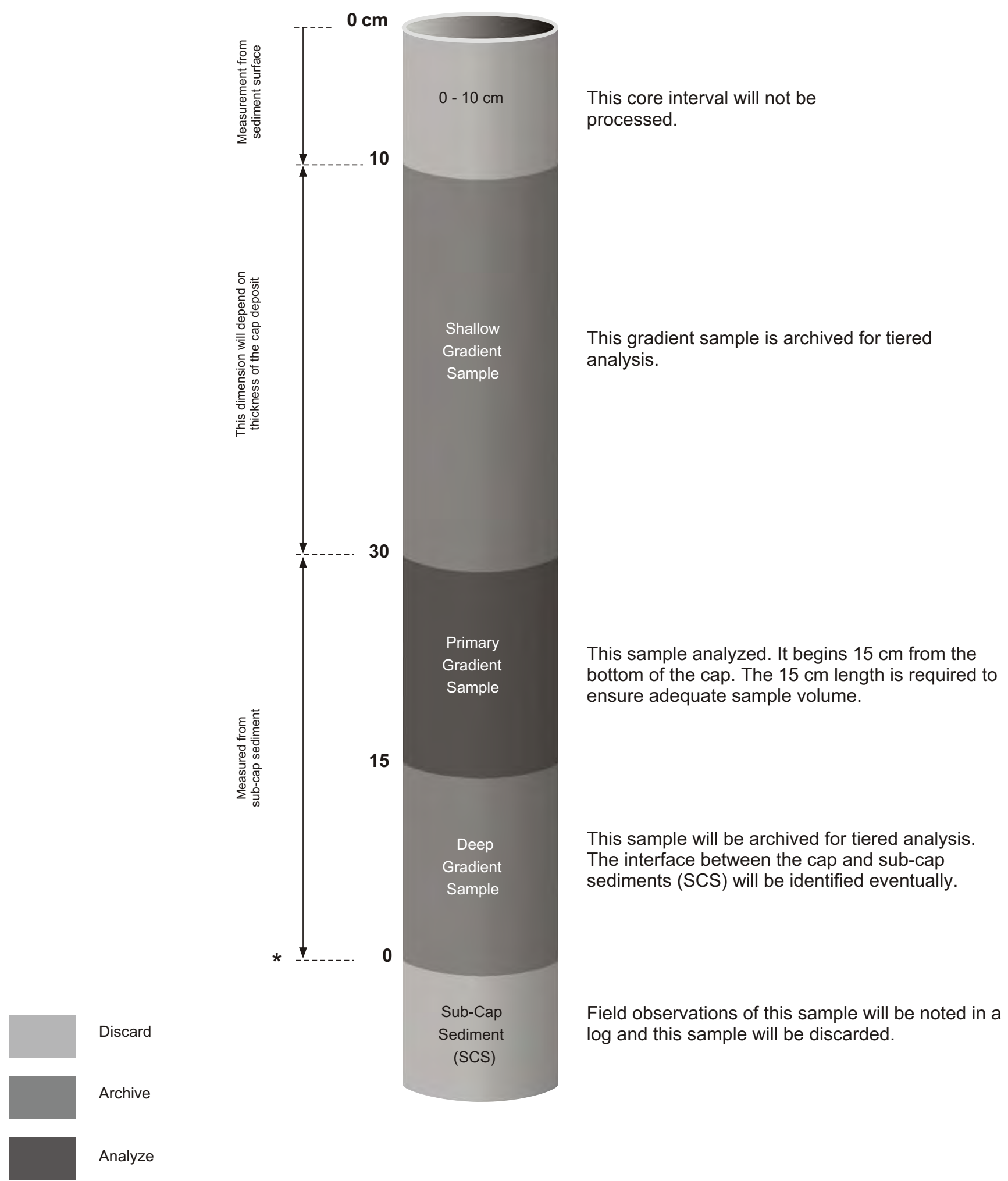
2016 OMMP Implementation
East Harbor Operable Unit
Wyckoff/Eagle Harbor Superfund Site

Intertidal Area Designations

Figure
1-3



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Sediment Core



* For where the cap has been augmented with additional cap sediments, gradient samples were measured from the Phase I/Phase II/Phase III boundary

Note: Utilized during the 1995, 1997, 1999, 2004, and 2011 monitoring events.

Project Name		Figure Name	
<div></div>		2016 OMMP Implementation East Harbor Operable Unit Wyckoff/Eagle Harbor Superfund Site	Gradient Sample Intervals of Through-Cap Cores Used in Previous Monitoring Events
			Figure 1-4



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2 Methods

This section presents a synopsis of the methods used to collect, analyze, and interpret the environmental data collected during the Year 22 monitoring program. This section also reports any significant deviations to the methods that were detailed in the 2016 OMMP Addendum (Appendix A), and in the Field Sampling Plan (FSP) and the QAPP (Appendix B).

Detailed supporting field and laboratory information may be found in the following appendices:

- C – Wyckoff/Eagle Harbor Evaluation of Sediment Cap Condition at EHO, prepared for WDNR by Integral Consulting, Inc.
- D – Clam tissue field report, tissue residue chemical values, and interpretive report (prepared by the USACE).
- E – Field Monitoring Report, including daily activity reports; surface and subsurface sampling locations; dates and times of collection; intertidal sampling locations with dates and times of collection; EBS cover measures; sample inventory; field notebooks; and chain-of-custody forms.
- F – Core logs and photographs and associated photos.
- G – Analytical laboratory reports for sediment chemistry.
- H – Data validation reports for the sediment chemistry analytical reports.
- I – Survey Program Technical Memorandum (includes a discussion of the results of the bathymetric and aerial surveys, and evaluates current physical stability and condition of the EBS).

Intertidal sampling on the EBS and West Beach was conducted by HDR Engineering, Inc. (HDR), and its subcontractor Science and Engineering for the Environment, LLC (SEE). Subtidal surface and subsurface sediment sampling was also conducted by HDR and SEE aboard the *R/V Nancy Ann*, owned and operated by Marine Sampling Systems of Burley, Washington. Representatives from EPA, USACE, and the Washington State Department of Ecology (Ecology) provided additional assistance and oversight of the sampling efforts. USACE previously conducted clam tissue sampling, based on the scope in the OMMP, in July 2016. Beach elevation surveys were directed by Miller Creek Aerial Mapping, LLC (MCA), with bathymetric surveys conducted by TerraSond, LTD (TerraSond).

A schedule of field activities is presented in Table 2-1. The physical and analytical sampling and analyses presented in this report were conducted in 2017. Clam tissue sampling and analyses were conducted in 2014 and 2016.

2.1 Navigation and Positioning

For subtidal sediment sampling, a differential Global Positioning System (DGPS) was used to navigate, occupy, and document over water stations aboard the *R/V Nancy Ann*.

The *R/V Nancy Ann* uses a Trimble AG 132 DGPS utilizing the US Coast Guard (USCG) differential signals from Vashon Island and Whidbey Island, Washington. Sampled stations were recorded in the field log book and interfaced to a computer running software, enabling real-time plan view navigation to the required sampling stations. Targeted sampling locations are listed in the FSP/QAPP (Appendix B); the occupied sampling stations are discussed below.

Prior to the start of each day's subtidal field collection, a known horizontal control point was occupied to demonstrate the accuracy of the positioning and navigation systems. The control navigation checkpoint, established in 2011 using USCG Navigational Aid buoy No. 4 located within the ferry lanes of Eagle Harbor, was used again in 2017. Navigation checks were generally made at least twice a day; one at the start of sampling and at the conclusion of sampling. Navigational checks are provided in Table 2-2; all daily navigation checks were within ± 2 m.

Intertidal sediment locations EBS and West Beach were recorded with a hand-held Trimble Geo Explorer 6000 DGPS. The DGPS was calibrated and position-verified immediately prior to field use. To navigate to the designated grid stations, the positions were pre-loaded into the DGPS. For the field-selected stations, a waypoint was set with the DGPS unit's memory for later downloading. Target coordinates are in the FSP; actual sampling coordinates are given in Table 2-3.

2.2 Physical Stability Monitoring

2.2.1 Exposure Barrier System and West Beach Bathymetric Surveys

A bathymetric survey as described in the Field Sampling Plan (Appendix B) in the vicinity of the EBS and West Beach was conducted by TerraSond on 11 January 2017. The flight to provide the airborne lidar acquisition was completed on 26 May 2017.

The methods used and the results of these surveys, as well as the additional surveys conducted to support evaluation of the current conditions of the EBS (lidar, aerial photography, etc.), are discussed in the technical memorandum included as Appendix I.

2.2.2 Exposure Barrier System Cover Measurements

EBS cover thickness was measured concurrent with the intertidal sediment sampling at EBS and West Beach at low tide on the night of January 13–14, 2017 (Appendix E, Daily Monitoring Report for 01132017). For each of the FSP-identified grid locations, three separate stations were measured to determine the thickness of the EBS cover or the near-surface material on West Beach. This was accomplished by driving a 4-ft-long, 5/8-inch-diameter piece of steel bar through the cover or beach material to refusal, and measuring the depth-of-drive. The sampled locations are shown in Figure 2-1.

Within each of the four FSP-designated grid sampling locations (D12, F12, H12, and I12), three separate cover measurements were collected. Of those, three grids were located on the EBS (west-to-east: F12, H12, and I12). The FSP-designated fourth grid (D12) is west of the EBS on West Beach (Figure 2-1); at this location, depth to refusal of the steel bar was measured and recorded. Measured depths of these four FSP-designated grid locations are given in Table 2-3.



Two discretionary grid locations were determined in the field by representatives of EPA, USACE, and Ecology. One discretionary location on the eastern end of the EBS was determined based on the apparent exposure of the underlying cobble layer of the EBS. Labelled in the field as the “discrete east” locations, three separate cover measurements were made within that discretionary grid location (Table 2-3). Post-sample plotting of the sample points identified that the location was in grid H12-c3 (Figure 2-1).

The second discretionary grid location was determined in the field by a representative from Ecology. Three discrete cover measurements, labelled as the “discrete west” locations, were collected at a location west and off of the EBS. This discretionary location was selected as being approximately half-way between the furthest planned west sampling location (D12) on the EBS and the western edge of the Pritchard Park. Post-sample plotting of the second discretionary location identified it as being within grid E11, and confirmed that the second discretionary grid location was outside (to the west) of the EBS and closer to off-site grid D12 (Figure 2-1). The sample rod was driven to refusal and the depth recorded (Table 2-3).

2.3 Chemical Monitoring

Chemical isolation monitoring in the Year 22 monitoring event was limited to the evaluation at the EBS/West Beach and off-EBS locations, as well as focused sampling at subtidal grid locations J9 and J10. Additional chemical monitoring was conducted at off-cap locations in the North Shoal subtidal area (J7, J8, K7, K8, and L8). Sampling included intertidal surface sediment collection (EBS/West Beach and off-EBS locations), subtidal cap surface sediment collection (J9 and J10), and subtidal off-site surface sediment collection (North Shoal subtidal area). Schedule of sampling events and the personnel involved is presented in Table 2-1. Methods for sediment collection and processing are documented in the FSP/QAPP (Appendix B); supporting field collection data are provided in the Field and Daily Monitoring Report (Appendix E) Methods for chemical analyses are discussed in Section 2.3.5.

2.3.1 Exposure Barrier System Sample Collection

A total of four grid locations on the EBS/West Beach and two off-EBS grid locations were sampled for surface sediments (0-2 ft) and analyzed for PAH, PCP, and conventional parameters (see Table 2-4 for summary of analytical program). Sampling locations are shown in Figure 2-1. Coordinates for the sampled locations are given in Table 2-3.

Intertidal surface sediment sampling required sampling at the extreme low tides, which occurred in the late night through early morning hours of 13 to 14 January 2017. Details concerning the tides and sampling personnel may be found in the daily monitoring reports for those days (see Appendix E).

For each designated grid station on EBS/West Beach (F12, H12, and I12) and off the EBS (D12), three individual samples were collected to produce one composite surface sediment sample. At each station, the location, date, time, and observations on the physical and biological condition within the sediments were noted. With the exception noted for the discretionary west location (discussed below), sediments were collected using a precleaned, 4-inch-diameter x 3-ft-long aluminum core tube driven to at least 2 ft below the sediment surface. The tubes were pounded in with a sledge hammer, and then

withdrawn by wrapping a chain wrench around the outside of the tube (see field photos in Appendix F). Once the three discrete samples at each location were collected, the samples were mixed (i.e., composited), placed into labelled sample jars, and then placed into an ice chest for transport.

The two discretionary grid locations were designated “discretionary east” and “discretionary west” in the field (Figure 2-1, Table 2-3). The same approach was used to collect sediment samples at the discretionary locations as the designated locations except for the samples collected at “discretionary east” grid location. At this location, because of the presence of the cobble layer, sediment collection was made by hand-digging with a trowel and collecting sediment between the cobbles down to 2 ft below mudline.

Post-sample plotting of the discretionary sample locations identified that the “discretionary east” location was in grid H12-c3 (Figure 2-1). The three discrete sample locations associated with this location were all collected in grid H12-c3, and were designated as H12-c3 west, mid, and east (Table 2-3). For the “discretionary west” location, post-sample plotting identified that location as being within grid E11-d4. Post-sample mapping of the grid locations demonstrated that those samples were outside (west) of the EBS and closer to off-EBS grid D12.

For each of the two discretionary grid locations, an archived sediment sample was collected from individual sampling location prior to compositing. These archive sediment samples were transferred under chain-of-custody to EPA’s laboratory in Manchester, Washington.

2.3.2 Subtidal Surface Sediment Collection

Subtidal surface sediment samples were collected on 23 and 24 January 2017; Table 2-1 presents the team members involved during each day of subtidal surface sediment sample collection. On-cap samples were collected within Grids J9 and J10. From the North Shoal subtidal area, samples were collected within each of five subtidal grids (J7, J8, K7, K8, and L8). See Figure 2-2 for subtidal sediment sampling locations.

From within each of the on-cap and North Shoal subtidal area grids, three discrete shallow grabs (0-10 cm below the mudline) were collected and composited into a single sample. The composite samples were submitted for analysis of PAH, PCP, mercury, and conventional parameters. For each discrete surface grab sampling locations, a single sediment sample to be archived was collected directly from the grab sampler prior to collection for the composite sample.

All surface sediment samples were collected with a stainless-steel, 0.1-m² double van Veen grab sampler deployed from the *R/V Nancy Ann*. The grab samples were inspected for acceptability and photographed prior to subsampling for compositing. Sampling locations and methods were consistent with the FSP/QAPP (Appendix B); detailed sampling observations are provided in the Field Monitoring Report (Appendix E). Table 2-5 presents the surface sample collection chronologically, along with sample identification numbers, nominal water depths, and collection notes; the analytical program for the subtidal composite samples is presented on Table 2-6.



2.3.3 Subtidal Subsurface Core Collection

Subtidal subsurface sediments were collected from five stations in the North Shoal subtidal area (Figure 2-3) on 20 January 2017; Table 2-1 presents the team members involved with subtidal subsurface core collection. Table 2-7 presents the subtidal core collection data including the date and time of collection, the position (latitude/longitude), nominal water depths and corrected water depths, and core tube penetration and acquisition.

Sediment coring occurred based on the procedures described in the FSP; details of collection can be found in the 20 January 2017 Daily Monitoring Report (Appendix E), and in the Core Drive Logs (Appendix F.1.). In all cases, the surface sediments were readily collected, but refusal was encountered between 4 and 7 ft bms as the corer encountered native glacial materials. The glacial till included coarse sand, gravel, and rocks that blocked further collection in the core tube and ultimately defined refusal of further penetration. Core composite photos are shown in Figures 2-4 and 2-5; core stratigraphy is further discussed in Section 3.2.2

Percent recovery in the cores was low (<60%) at the two grid locations furthest offshore (J7 and J8). At target location J8-c5, the first core collected was rejected due to poor recover (43%). A second core at that same location was attempted; recovery was even less at 34%. A third attempt in grid J8 was made by moving to J8-c3; while the recovery was marginally better (46.8%), the presence of glacial till prevented adequate collection. For all five grids, the target collection of 2 ft bms defined in the FSP was achieved.

Each collected core was capped, taped, labelled, and transported upright to the Analytical Resources, Inc. (ARI), facility in Tukwila where they were held upright at 4° C until processed.

2.3.4 Core Sectioning and Processing

Core processing occurred at ARI on 25 January 2017; Table 2-1 presents the team members involved with core processing. The processing and logging of the cores followed the steps below:

1. The cores were split longitudinally by scoring the sides of the aluminum tube with a circular saw.
2. Once scored, the cores were opened and placed on a foil-covered table.
3. The cores were photographed.
4. The cores were logged, noting stratigraphy and the presence/absence of odor and sheen/staining.
5. Remaining sediment from the cores was transferred to containers for disposal.

Specifics of the core sampling and processing can be found in the Field Monitoring Report (Appendix E). Core logs and associated photographs are provided in Appendix F.

2.3.5 Laboratory Methods

Laboratory analyses of sediment and water samples collected during the Year 22 monitoring program were conducted in accordance with the methods and procedures

prescribed in the approved 2016 QAPP (HDR, SEE, and MCA 2017).⁶ The QAPP covering management of the sediment and water samples is provided in Appendix B of this monitoring report. ARI of Tukwila, Washington, conducted the chemical analyses of the sediment and water samples. An inventory of the samples at the laboratory and the analyses conducted is given in Tables 2-4 and 2-6. The analytical data reports are provided in Appendix G. The clam tissue analyses were performed by the EPA Region 10 Manchester Laboratory in accordance with the USACE sampling plan, as discussed further in the following section.

A quality assurance review of the sediment chemistry data was conducted and is provided in Appendix H. This review included evaluation of precision, accuracy, representativeness, comparability, and completeness (PARCC) according to the criteria specified in the project QAPP. With respect to PARCC parameters, all data are considered valid and acceptable.

2.4 Biological Monitoring

For the Year 22 monitoring report, biological monitoring was limited to collection and analyses of clam tissue in 2014 and in 2016. This work was conducted directly by the USACE with laboratory analysis conducted at EPA Region 10's Manchester Analytical Laboratory. The 2014 and 2016 collections were conducted following separate QAPPs prepared for the clam tissue sampling and analyses (Appendix D.1 and D.2). Collection-specific methods are discussed below.

2.4.1 Clam Tissue Collection

2014 Sample Collection

The USACE collected clams on 16 May 2014 at three separate locations within each of four intertidal areas, including the Intertidal Cap, North Shoal, West Beach, and East Beach locations (Appendix D.3). Clams were collected within the same time window (i.e., month of May) as in the 2003 and 2011 monitoring events. Prior to the clam tissue collection, a reconnaissance survey was conducted on 29 January 2014 to determine if sufficient clams would be present for tissue collection and analysis in the West Beach area, since none were found at this location during the 2011 event. Based on that survey, horse clams (*Tresus capax*) were found in sufficient numbers on the West Beach/EBS and were included in the 2014 collection.

Procedures for the collection and analyses of clam tissue generally followed the 2014 QAPP for Clam Tissue Sampling (Appendix D.1). Clams were not collected using a grid system since the primary objective was to collect enough clams for tissue analysis within the separate sampling locations. Clams were collected from the locations proximal to areas previously sampled in 2003 and 2011, to the extent practicable. The general collection sites were GPS located rather than at each specific hole from which clams were collected. A general GPS reading was taken for all sample locations on West Beach, North Shoal, East Beach, and the Intertidal Cap; GPS information was not

⁶ Clam tissue was collected and managed directly by USACE in July 2016 (Appendix D).



collected at each individual clam sample location. Clam sampling locations are shown in the 2014 report (Appendix D.3, Figure 1).

All clams were rinsed before being placed in coolers with ice, and were hand-delivered to EPA's Manchester Laboratory under chain-of-custody at the end of each collection day.

2016 Sample Collection

The USACE collected horse clams (*T. capax*) for tissue analysis from the intertidal areas of the West Beach, Intertidal Cap, North Shoal, and East Beach were sampled on 5 July 2016; the background location was sampled on 6 July 2016. Procedures for collection and analyses are documented in the 2016 QAPP for Clam Tissue Sampling (Appendix D.2). The 2016 Clam Tissue Collection Report is provided in Appendix D.4.

The 2016 sampling locations are shown in Figure 2-6. The Project Quality Objective in the USACE's clam tissue QAPP was to collect three *T. capax* clams within each of the four EHO intertidal areas (total of 12 clams), and three from a background location, for a total of 15 clams. Based on the documentation in the data report, it was difficult to locate horse clams (*T. capax*). Three clam collections were made at West Beach (on the EBS), the Intertidal Cap, and East Beach. For the North Shoal, only a single clam was found; for the West Beach, insufficient clams were found to include a field replicate for that location. For the East Beach collection, it was necessary to accept the horse clam species (*T. nuttallia*) as samples for the East Beach area.

At the request of EPA, USACE also collected varnish clams (*Nuttallia obscurata*) from the Wyckoff site in order to determine abundance and tissue weight per clam. No chemical analyses were performed on the clam tissue. The collection was completed to draw conclusions on the presence of this clam species at the site for possible future sampling, if desired.

Varnish clams were located throughout the West Beach and Intertidal Cap areas at approximately 2 to 4 inches beneath the surface. Sixty varnish clams collected from the Intertidal Cap area were sent to the lab for tissue weight. Varnish clams were not identified on the North Shoal or East Beach. At the Manchester laboratory, the clams were shucked and weighed to determine the number of clams needed to provide sufficient tissue to perform potential future analyses.

Part of the goal of this sampling effort was to retrieve background horse clam tissue data. In coordination with the Suquamish Tribe, it was determined that Point No Point Park, located on the northern end of Kitsap Peninsula, would provide an acceptable background level for clams in the Central Puget Sound, including at the Wyckoff site. On 6 July 2016, representatives of USACE, EPA, and the Suquamish Tribe attempted to collect clams at Point No Point Park (Figure 2-7). However, the clams that were found on this beach were primarily horse clams of the species *T. nuttallii*, and not the desired *T. capax*. The sampling team could find only a single clam (*T. nuttallii*) for sample analysis.

2014 and 2016 Laboratory Methods

The clam tissue samples collected by USACE were transferred under chain-of-custody to EPA Region 10's Manchester Environmental Laboratory. The tissue analyses were done in accordance with the 2016 Clam Tissue QAPP (Appendix D.2).

A minimum of 100 grams of clam tissue (whole body without shell) were required for each composite for analysis of PAH and lipids (prior to analysis, the gutball contents were removed and discarded and the inside of the gutball was rinsed with deionized water). Clams were not depurated prior to processing. The laboratory process included resectioning of the entire clam tissue, removing the outer skin and hard tip from the neck, discarding the contents of the gutball (emptying the gutball and retaining gutball tissue for analysis), homogenizing the composite samples, and freezing the samples in glass jars at -18°C for later analysis. Thus, horse clam tissue samples included skinned neck (hard tip removed), strap, and empty gutball. The tissue sample preparation and homogenization procedure was modified from the Washington Department of Health's (DOH) Technical Assistance for Preparing Geoduck Tissue Samples (DOH 2011).

The Manchester Environmental Laboratory limit of quantitation (LOQ) for the seven cPAHs is estimated to range from 1 to 2 µg/kg. This range of LOQs is calculated to resolve between 6.06 E-6 and 1.21 E-5 cancer risk for the child Tribal subsistence consumer. The tissue samples were extracted using EPA Method 3550-M modified (industrial blender), cleaned up using EPA Method 3660B, 3665A, and 3640A, if needed, and analyzed for PAHs using EPA Method 8270D select ion monitoring (SIM) modified as necessary to achieve the required reporting limits. Lipids were analyzed gravimetrically by EPA method 3541C (MeCl₂ extraction), and then by the method of Bligh and Dyer (1969). The laboratory reported the total weight for each homogenized sample.

According to the USACE's report summarizing the results of the 2016 sampling, the single clam collected at the North Shoal did not provide the lab with the minimum amount of tissue sample needed to run the standard 8270D analysis for PAHs (Appendix D.5). USACE contacted the Manchester Environmental Laboratory, which indicated they could run 8270D analysis on whatever tissue was recovered; however, the lab also indicated that there may be a higher reporting associated with this sample, due to lack of sufficient tissue mass recovered.

Data Quality Review

A Quality Assurance Review (QAR) for the 2016 collection was conducted by the EPA laboratory for both PAHs and lipid clam tissue analyses. These QARs are included in Appendix D.6 and D.7.

Table 2-1. Field Activities Schedule and Personnel

Date Activity		Project Team Member								
		HDR	SEE	USACE	USEPA	Ecology	TerraSond	GeoTerra	APS	GPS Surveying
1/11/2017	Bathymetric Survey						X			
1/13/2017	EBS and West Beach Sampling	X	X	X	X	X				
1/14/2017	EBS and West Beach Sampling	X	X	X	X	X				
1/19/2017	Mobilization for Subtidal Field Work	X	X							
1/20/2017	Subtidal Surface Sediment Chemistry Sampling	X	X	X		X				
1/23/2017	Subtidal Subsurface Coring	X	X		X					
1/24/2017	Subtidal Subsurface Coring	X	X			X				
1/25/2017	Core Processing	X	X			X				
1/30/2017	Orthophotographic Survey									X
5/26/2017	LIDAR Survey							X	X	

Notes:

APS - APS Surveying and Mapping

EBS - Exposure Barrier System

Ecology - Washington State Department of Ecology

GPS Surveying - GPS Surveying, Inc.

HDR - HDR Engineering, Inc.

SEE - Science and Engineering for the Environment, LLC

USACE - US Army Corps of Engineers

USEPA - US Environmental Protection Agency

Table 2-2. Daily Navigation Checks

Horizontal Control Point: NAVAID					
Date	Time	Target Waypoint (NAD 83)		Navigation Check Coordinates (NAD	
		Latitude N	Longitude W	Latitude N	Longitude W
1/20/2017	9:02	47° 37.31925'	122°29.84328'	47°37.31935'	122°29.84526'
1/23/2017	9:15			47°37.31947'	122°29.84553'
1/24/2017	8:57			47°37.31934'	122°29.84549'
1/23/2017	16:31			47°37.31945'	122°29.84574'
1/24/2017	12:32			47°37.31914'	122°29.84498'

Notes:

N - North

NAD 83 - The North American Datum of 1983

NAVAID - Navigation Aid

W- West

Table 2-3. Exposure Barrier System Cover Measurements and Sediment Sample Locations

2016 Grid Cell Station	Latitude (NAD 83 N)	Longitude (NAD 83 W)	Collection Date	Collection Time	Depth to Refusal (ft)	Core Drive Depth (ft)	Acquisition (ft)	Archive Retained	Composite Sample Blind ID	Comments
Off-EBS Sample Locations										
D-12										
D12-d1	47°36.9787'	122°30.5513'	1/13/2017	21:11	0.90	1.00	0.95	X	011317001	
D11-e5	47°36.9858'	122°30.5423'		21:25	2.00	2.00	1.90	X		
D11-c5	47°36.9888'	122°30.5610'		21:42	2.00	2.00	1.90	X		
E-11*										
E11-d4 east	47°36.9925'	122°30.4857'	1/14/2017	2:05	1.90	1.05	1.10	X	011317006 011317007	MS/MSD Field Replicate
E11-d4 mid	47°36.9950'	122°30.4888'		1:55	1.90	1.40	1.30	X		
E11-d4 west	47°36.9930'	122°30.4933'		2:15	2.10	1.70	1.60	X		
2016 Grid Cell Station	Latitude (NAD 83 N)	Longitude (NAD 83 W)	Collection Date	Collection Time	Measured Depth of EBS Cover (ft)	Core Drive Depth (ft)	Acquisition (ft)	Archive Retained	Composite Sample Blind ID	Comments
EBS Sample Locations										
F-12										
F12-d1	47°36.9792'	122°30.4267'	1/13/2017	22:49	1.50	1.00	n.d.	---	011317002	
F11-c5	47°36.9893'	122°30.4362'		22:32	2.00	1.50	n.d.	---		
F11-e5	47°36.9863'	122°30.4177'		23:02	2.00	1.50	1.50	---		
H-12										
H12-a2	47°36.9768'	122°30.3503'	1/13/2017	23:25	2.00	1.65	1.65	---	011317003	
H12-a1	47°36.9810'	122°30.3468'		23:45	2.20	1.50	1.50	---		
H12-b2	47°36.9743'	122°30.3337'		23:55	2.05	1.50	1.50	---		
H-12**										
H12-c3 west	47°36.9670'	122°30.3253'	1/14/2017	1:17	0.00	Underlying cobble exposed. Hole hand-dug to 2 ft and sand extracted for sample composite	---	011317005		
H12-c3 mid	47°36.9653'	122°30.3197'		1:17	0.00		---			
H12-c3 east	47°36.9652'	122°30.3160'		1:17	0.00		---			
I-12										
I12-c3	47°36.9667'	122°30.2598'	1/14/2017	0:16	2.35	1.60	1.60	---	011317004	
I12-b2	47°36.9727'	122°30.2712'		0:24	2.00	1.50	1.45	---		
I12-e2	47°36.9762'	122°30.2363'		0:35	0.95	1.00	n.d.	---		

* Discretionary Off-EBS Sample Location

** Discretionary EBS Sample Location

Notes:

⁰ - degrees

EBS - Exposure Barrier System

FSP - Field Sampling Plan

ft - feet

ID - Identification

MS/MSD - Matrix Spike/ Matrix Spike Duplicate

N - North

NAD 83 - The North American Datum of 1983

W- West



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Table 2-4. Inventory of Exposure Barrier System Sample Locations and Analyses Program

2016 Grid Station	Collection Date	Collection Time	Composite Sample Blind ID	Conventional (TOC, Total Solids)	Grain Size	PCP by 8041	PAHs by 8270 SIM	Comments
Off-EBS Sample Locations								
D-12	1/13/2017	21:11	011317001	X	X	X	X	
E-11*	1/14/2017	1:55	011317006	X	X	X	X	Includes MS/MSD
			011317007					Field Replicate
EBS Sample Locations								
F-12	1/13/2017	22:47	011317002	X	X	X	X	
H-12	1/13/2017	23:32	011317003	X	X	X	X	
H-12**	1/14/2017	1:17	011317005	X	X	X	X	
I-12	1/14/2017	0:16	011317004	X	X	X	X	

* Discretionary Off-EBS Sample Location

** Discretionary EBS Sample Location

Notes:

⁰ - degrees

cm - centimeter

EBS - Exposure Barrier System

FSP - Field Sampling Plan

ft - feet

ID - Identification

MS/MSD - Matrix Spike/ Matrix Spike Duplicate

N - North

NAD 83 - The North American Datum of 1983

PAH - polycyclic aromatic hydrocarbon

PCP - pentachlorophenol

SIM - Select Ion Monitoring

TOC - total organic carbon

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Table 2-6. Inventory of Subtidal Sediment Sample Locations and Analyses Performed

2016 Grid Cell	Collection Date	Collection Time	Blind Sample ID	Conventionals (TOC, Total Solids)	Grain Size	PCP by 8041	PAHs by 8270 SIM	Mercury	Notes
J7	1/13/2017	9:32:44 AM	012317001	X	X	X	X	X	
K7	1/13/2017	11:04:55 AM	012317002	X	X	X	X	X	
J8	1/13/2017	2:41:20 PM	012317003	X	X	X	X	X	
K8	1/13/2017	3:48:37 PM	012317004	X	X	X	X	X	
L8	1/13/2017	9:09:49 AM	012417001	X	X	X	X	X	
J9	1/13/2017	10:15:16 AM	012417002	X	X	X	X	X	
			012417003						Field Replicate
J10	1/13/2017	11:50:39 AM	012417004	X	X	X	X	X	Includes MS/MSD

Notes:

ID - Identification

MS/MSD - matrix spike/matrix spike duplicate

PAH - polycyclic aromatic hydrocarbon

PCP - pentachlorophenol

SIM - Select Ion Monitoring

TOC - total organic carbon

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Table 2-7. Subtidal Core Sample Locations

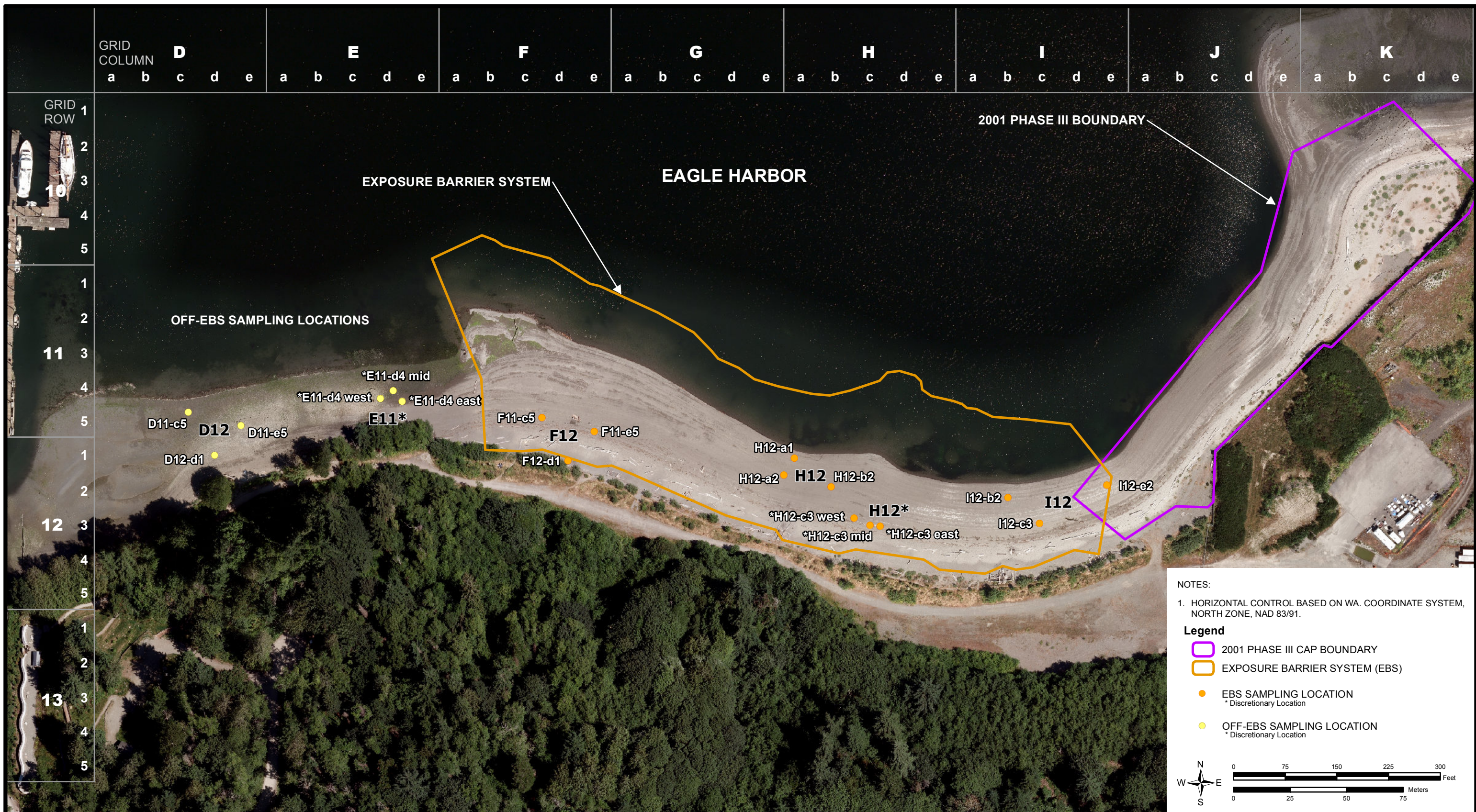
2016 Grid Cell Station	Attempt	Collection Date	Collection Time	FSP Target Sampling Locations		Actual Sampling Locations		Measured Water Depth (ft)	Tidal Height at Time of Collection (ft MLLW)	Corrected Collection Depth (ft MLLW)	Penetration (ft)	Acquisition (ft)	% Recovery	Comment
				Latitude (NAD 83 N)	Longitude (NAD 83 W)	Latitude (NAD 83 N)	Longitude (NAD 83 W)							
J8-c5	c1	1/20/2017	9:14:34	47°37.11550'	122°30.20283'	47°37.11574'	122°30.20129'	25.8	12.2	-13.6	4.65	2.0	43.0%	Rejected
J8-c5	c2	1/20/2017	9:40:29	47°37.11550'	122°30.20283'	47°37.11528'	122°30.20146'	26.5	12.6	-13.9	5	1.7	34.0%	
K8-c5	c1	1/20/2017	10:17:54	47°37.11633'	122°30.14167'	47°37.11668'	122°30.14176'	16.8	12.9	-3.9	7	4.7	67.1%	
L8-c5	c1	1/20/2017	10:52:28	47°37.11683'	122°30.08100'	47°37.11640'	122°30.08187'	15.1	12.9	-2.2	7	4.5	64.3%	
K7-c5	c1	1/20/2017	11:10:45	47°37.15717'	122°30.14300'	47°37.15716'	122°30.14245'	22.8	12.8	-10.0	7	4.6	65.7%	
J7-c5	c1	1/20/2017	11:37:10	47°37.15633'	122°30.20383'	47°37.15569'	122°30.20065'	16.3	12.5	-3.8	7	3.6	51.4%	
J8-c3	c1	1/20/2017	12:14:09	---	---	47°37.13253'	122°30.19381'	17.1	11.9	-5.2	4.7	2.2	46.8%	Attempted a second location in Quadrant J8

Notes:

% - percent
° - degrees
FSP - Field Sampling Plan
ft - feet

ft MLLW - feet mean lower low water
N - North
NAD 83 - The North American Datum of 1983
W - West

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Project Name

Figure Name



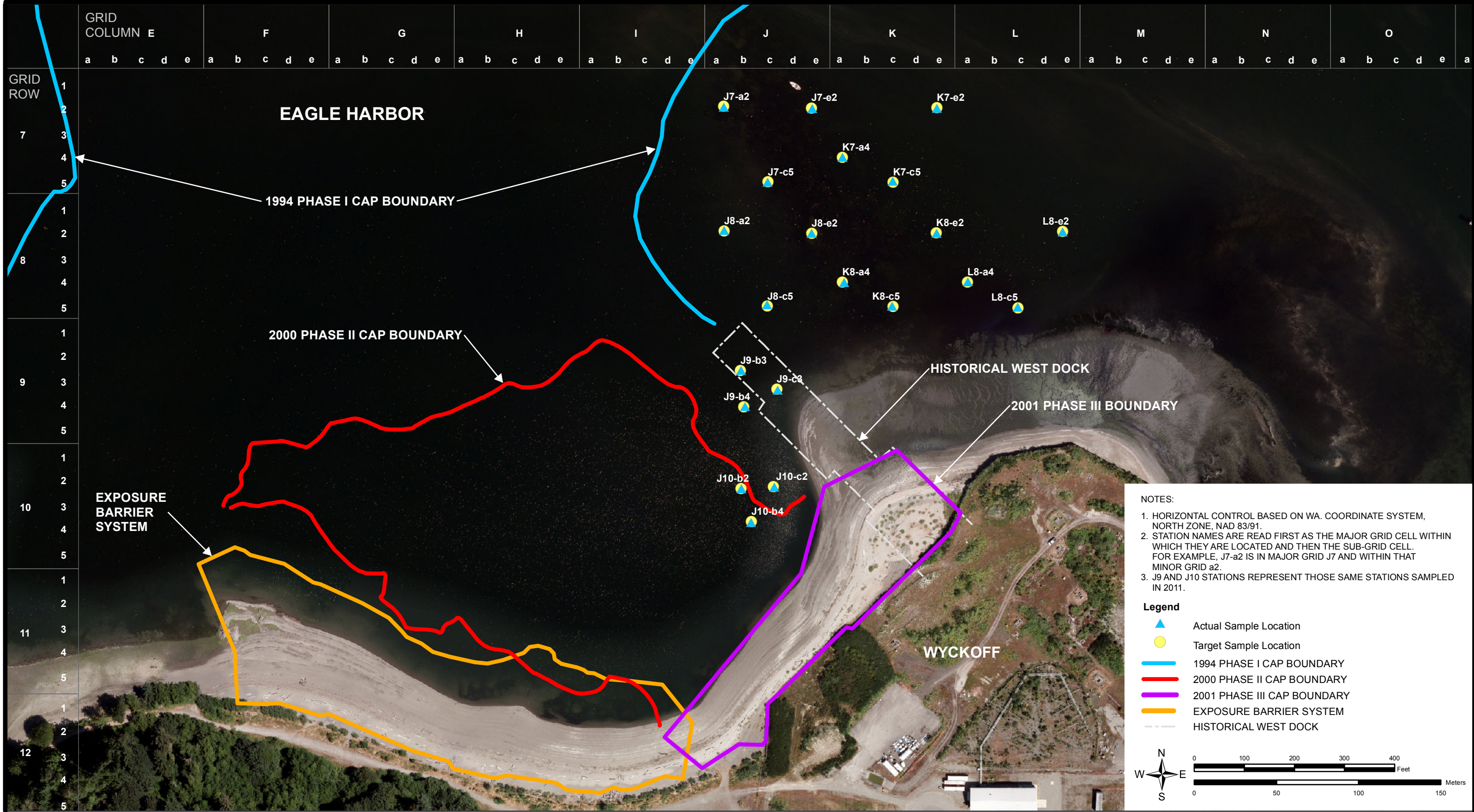
2016 OMMP Implementation
East Harbor Operable Unit
Wyckoff/Eagle Harbor Superfund Site

Exposure Barrier System and Off-Exposure
Barrier System Sampling Locations

Figure
2-1



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2016 OMMP Implementation
East Harbor Operable Unit
Wyckoff/Eagle Harbor Superfund Site

Subtidal Surface Sediment Target
and Actual Sampling Locations

Figure
2-2

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Project Name

Figure Name



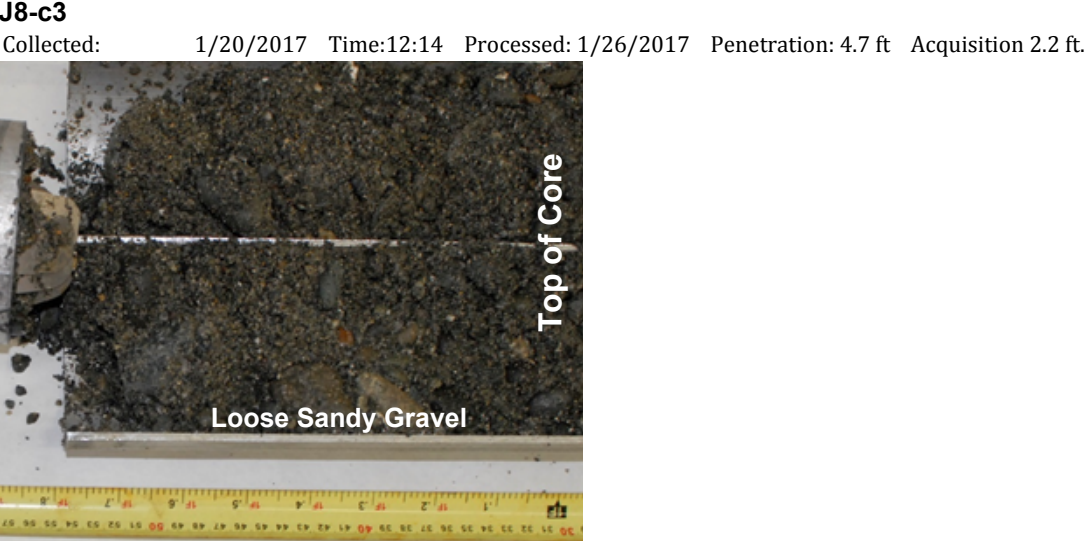
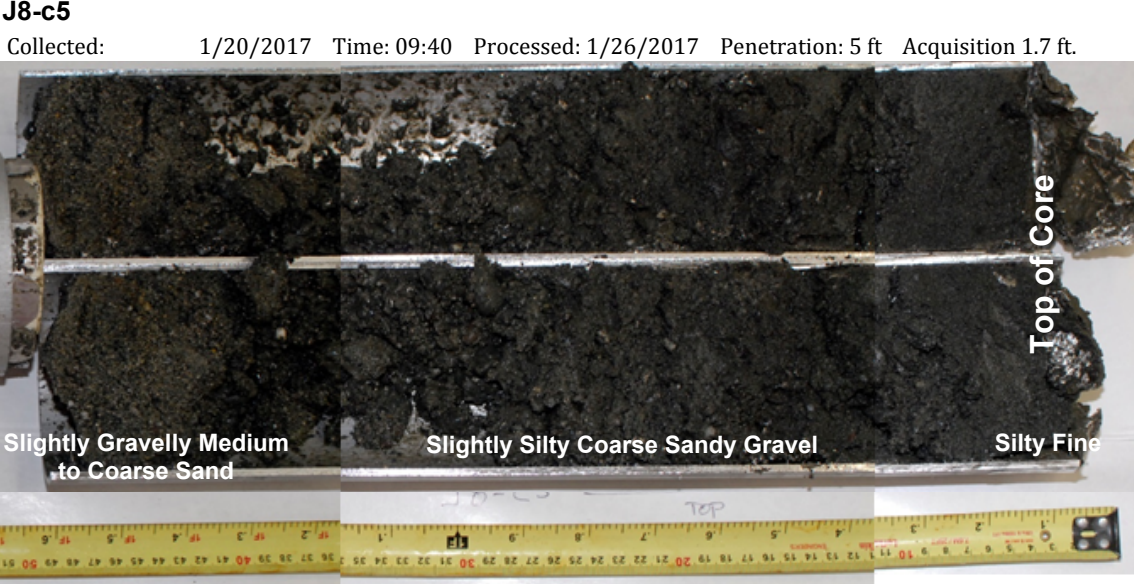
2016 OMMP Implementation
East Harbor Operable Unit
Wyckoff/Eagle Harbor Superfund Site

Subtidal Core
Target and Actual Sampling Locations

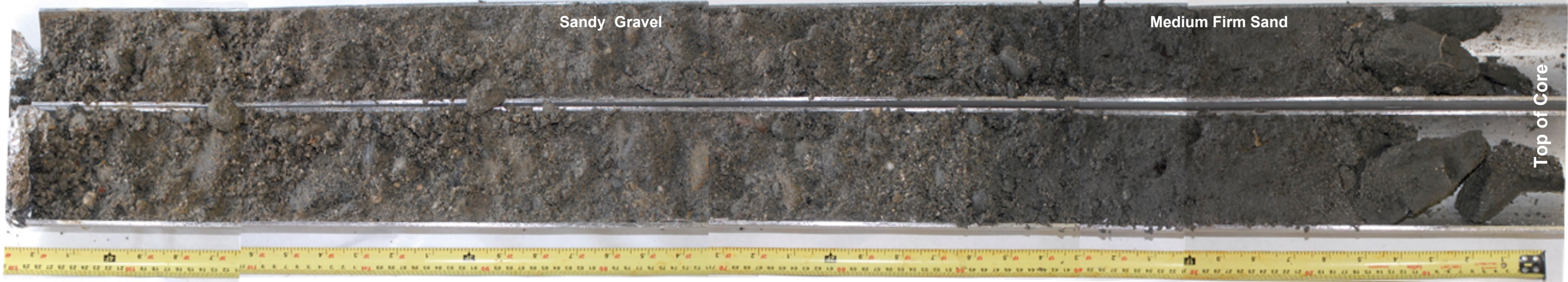
Figure
2-3

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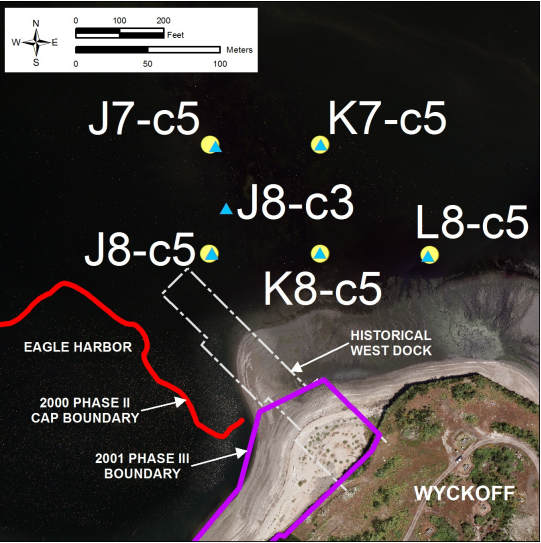
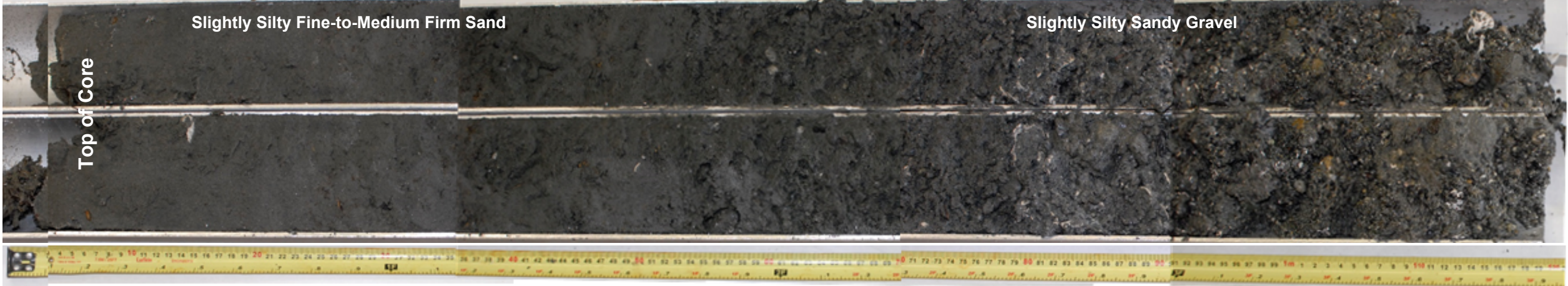
J8-c5 (Core Collected, Rejected)
Collected: 1/20/2017 Time:09:14 Penetration: 4.65 ft Acquisition 2.0 ft
Processed: Rejected





K8-c5
Collected: 1/20/2017 Time: 10:17 Processed: 1/26/2017 Penetration: 7.0 ft Acquisition 4.7 ft.



L8-c5
Collected: 1/20/2017 Time: 10:52 Processed: 1/26/2017 Penetration: 7.0 ft Acquisition 4.5 ft.



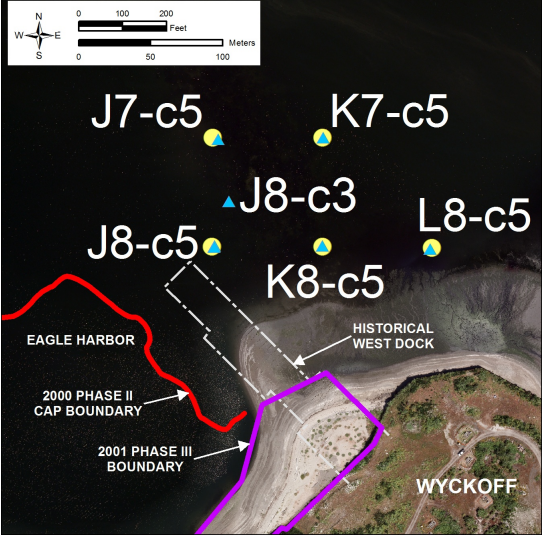
Project Name		Figure Name	
 		2016 OMMP Implementation East Harbor Operable Unit Wyckoff/Eagle Harbor Superfund Site	
		Subtidal Sediment Core Composite Details (J8, K8, and L8)	
		Figure 2-4	



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J7-c5

Collected: 1/20/2017 Time:11:36 Processed: 1/26/2017 Penetration: 6.7 ft Acquisition: 3.6 ft



K7-c5

Collected: 1/20/2017 Time:11:10 Processed: 1/26/2017 Penetration: 7.0 ft Acquisition: 4.6 ft



Project Name

Figure Name



Science & Engineering for the Environment

2016 OMMP Implementation
East Harbor Operable Unit
Wyckoff/Eagle Harbor Superfund Site

Subtidal Sediment Core
Composite Detail (J7 and K7)

Figure
2-5



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Y:\Wyckoff\East Harbor OMMP\2016 OMMP\GIS\Figure1_EHOU CapLocation_SampleLocs.mxd

Project Name

2016 OMMP Implementation
East Harbor Operable Unit
Wyckoff/Eagle Harbor Superfund Site

Figure Name

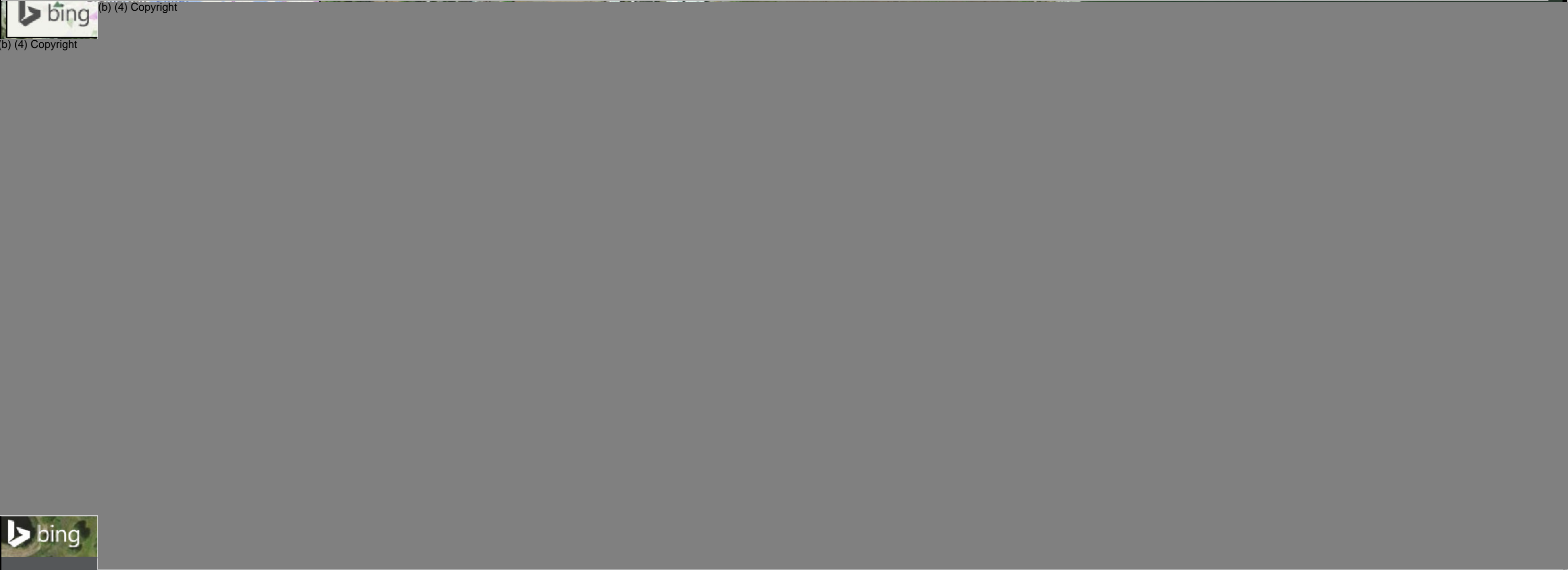
Location of Clam Tissue Sampling Points
at the Wyckoff/Eagle Harbor Site

Figure
2-6





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3 Results

This section presents the results of the Year 22 monitoring program for the EHOU completed in 2017. The data presented herein form the basis for evaluating the present environmental conditions relative to the area and monitoring objectives defined in Table 1 of the 2016 OMMP Addendum (Appendix A) and presented in this document in Table 1-2.

3.1 J9 and J10 Sediments

The area defined by sample grid locations J9 and J10 was the target of additional characterization and evaluation in the Year 22 monitoring program. Within each of the two grids, three discrete surface sediment samples were collected, composited, and analyzed (two composite samples total). These were the same sample locations last investigated in the Year 17 monitoring. Observations on the collected surface sediment samples and surface sediment chemistry results are discussed below.

3.1.1 Physical Stability Observations (J9 and J10)

Consistent with observations made in the 2011 monitoring, the immediate sediment surface in the vicinity of J9 and J10 sampling grids was a veneer of silty-clay overlying sandy gravels. In part, the underlying material appeared consistent with the Phase II/III Intertidal Cap material. In sampling grid J9, two of the discrete sampling locations (J9-b3 and J9-b4) had surface sediments composed of fine, slightly sandy silty-clay, while the discrete third station (J9-c3) was principally sandy gravel overlain with a thin veneer of trace silt.

In sampling grid J10, all three discrete sampling locations had a relatively thin veneer of trace sand, silty-clay at the surface, which overlaid a coarse sand, rounded gravel mix. The rounded gravel mix (< 2 cm) strongly resembles the Phase II/III cap habitat mix. At all six discrete sampling locations, no evidence of any Phase 1 capping material or immediate evidence of hydrocarbons was identified. However, small (1–3 mm) sheens did appear in the subsequent two composite samples.

3.1.2 Surface Chemistry Results (J9 and J10)

Table 3-1 presents the results for the analyses identified for the J9 and J10 subtidal sediment composite samples; sample locations are presented in Figure 3-1. The PCP and PAH analytical results were evaluated both on a dry-weight basis and as concentrations normalized to TOC. For stations with TOC concentrations between 0.5% and 3.5%, the data were organic carbon (OC)-normalized and screened against the SQS and MCUL criteria. For stations with TOC below 0.5%, the dry weight PAH and PCP data were screened against LAETs for each individual compound and total LPAH and HPAH values.

The chemical evaluation of the J9 and J10 sampling grids are intended to further inform potential remedial actions for the area of the former historical West Dock. Results for the composite samples at J9 (and the replicate for J9) and J10 are presented in Table 3-1; results exceeding relevant criteria at the discrete sampling locations are presented in

Figure 3-1. For both these grid composites, the grains size was approximately 77% sand/gravel; the apparent Phase III gravel component was approximately 30% by weight. The TOC for these two composite samples ranged between 1.52 and 1.98%; organic chemical results were thus OC-normalized (reported as mg/kg OC) and compared directly to the SMS criteria.

All measured chemicals of concern at J9 and J10 were below the corresponding SQS/MCUL criteria. The total LPAH concentration at J9 and J10 was reported at 47.4 mg/kg OC (63.6 mg/kg OC for the J9 replication) and 22 mg/kg OC, respectively. The total HPAH concentrations were measured at 437 mg/kg OC (416.8 mg/kg OC for the J9 replicate) and 93.3 mg/kg OC, respectively.

The EPA's Proposed Plan (2016) for OU1 includes preliminary remediation goals (PRGs) for cPAHs as TEQs in beach sediments. These proposed goals would be used to compare average concentrations of COCs in the top 2 ft of intertidal sediments. While not specifically included as a performance measure in the 2016 OMMP, EPA requested that all sediment data (intertidal and subtidal) be evaluated for levels of cPAHs.

Table 3-2 presents the bulk sediment cPAH results, and calculates the cPAH PRG two ways, using both the MTCA TEF/TEQ approach and the EPA (1993) RPF and benzo(a)pyrene equivalence (B[a]P EQ) method. As EPA has not established final remediation goals for the proposed ROD amendment, the results of these cPAH calculations are presented here for consideration only, without further comparison or discussion.

PCP was non-detect at 0.59 U mg/kg OC-normalized for both stations; well below the SQS criterion. Mercury was measured at 0.1076 mg/kg (0.09953 mg/kg for the J9 replicate) and 0.131 mg/kg, respectively; both results are below the SQS criterion.

3.2 North Shoal Subtidal Surface Sediment Results

Surface sediment sampling and subsurface coring were completed in the North Shoal subtidal area. The purpose of this sampling was to evaluate the following performance criteria:

1. Are sediments in the biologically active zone (0–10 cm) clean, relative to the Washington SMS?
2. Are hydrocarbons present in the top 2 ft below the sediment surface?

The following section provides the results of the North Shoal subtidal sediment sampling that can then be used to inform evaluation of these performance criteria.

3.2.1 North Shoal Area Subtidal Surface and Subsurface Physical Observations

Physical collection data for the North Shoal area subtidal surface locations are presented in Tables 2-5. Physical descriptions of the surface sediments are presented in the Field Monitoring Logs (Appendix E); photographs of the surface grabs are located in Appendix F. North Shoal subtidal surface sediment sampling locations are presented in Figure 3-1. Depths of these stations ranged from -2 to -5 ft MLLW in the nearshore



stations (J8-c5, K8-c5, and L8-c5) and up to approximately -31 ft MLLW at the furthest offshore stations (J7-a2, J7-e2, and K7-e2).

Surface sediment at all five North Shoal subtidal sample locations were principally coarser materials comprising roughly between 78% and 93% sands with gravel. Coarse sand with gravels and cobble were identified at the furthest offshore stations (i.e., J7 and K7). The composite grain size result for J7 was 93% coarse material with 16.8% gravel, and for K7 was 87% coarse material with 9.8% gravel. The three near-shore grids (i.e., J8, K8, and L8) were fine-to-medium sands (ranging between 78% and 89%), but with substantively less gravel (between 1% and 4.8%). Small (2–5 mm diameter) blebs of hydrocarbon were noted at the following grab locations: J7-a2, J7-e2, K7-a4, J8-a2, J8-c5, K8-c5, and L8-e2 (see Table 2-5). Small blebs (2–3 mm diameter) of hydrocarbon were also noticed in the composite samples for J7 and L8, but not for K7, K8, or J8.

Collection data for the subtidal core samples are given in Table 2-7, sampling locations are shown in Figure 2-3. Composite photos of the cores are shown in Figures 2-4 and 2-5. Core logs and associated photographs are provided in Appendix F.

The stratigraphy of the subsurface sediments at the North Shoal sampling locations is consistent with that observed in the surface sediment samples. Coarse sand with sub-rounded gravels at the surface, to gravels at depth with sand. Hydrocarbons were not apparent in any core sample; odors, sheens, or the presence of NAPL was not observed.

3.2.2 North Shoal Area Subtidal Surface Chemical Results

Analytical results for the North Shoal subtidal composite samples are presented in Table 3-1. Overall, the chemicals of concern in the biologically-active zone are below the SQS/MCUL. No exceedances for mercury or PCP were identified in any of the five composite samples. With the exception of the composites for K8 and L9, individual PAH concentrations were measured at levels below the SQS. For K8 and L8 the exceptions were as follows:

- The K8 composite result for acenaphthene is 118 µg/kg dry weight (dw). When normalized to the 0.67% TOC, the value of 17.61 mg/kg OC is above the corresponding SQS of 16 mg/kg OC. The reported dry weight value is, however, below the LAET value of 500 µg/kg.
- The L8 composite results for acenaphthene, fluorene, and phenanthrene are reported as 206 µg/kg dw, 241 µg/kg dw, and 676 µg/kg dw, respectively. Normalized to the TOC of 0.66%, the values become 31.21 mg/kg OC, 36.52 mg/kg OC, and 102.42 mg/kg OC, respectively. The OC-normalized values for these three PAHs are above the corresponding SQS values. The reported dry weight values are all are below their respective LAET criterion.

Results exceeding relative criteria are also presented by sample location in Figure 3-1.

The apparent SQS exceedances at K8 and L8 are identified only when the dry weight results are normalized to TOC; 0.67% and 0.66%, respectively. The SMS does not require OC-normalization only when the TOC is out of the range of 0.5% to 3.5%. It is worth noting that in replicate samples taken from the composite for J9, the reported TOC was 1.52% and 1.98%, a difference of 0.46% for the same sample. Given the low TOC for the K8 and L8 sample locations, the variability in TOC measures from the primary and

replicate sample at J9, and that the dry-weight values for the individual PAHs were well below the corresponding LAET, the levels of acenaphthene, fluorene, and phenanthrene may be at levels that would likely not pose risk to benthic organisms.

Table 3-2 presents the bulk sediment cPAH results for the North Shoal subtidal stations, and calculates the MTCA TEQs and the EPA B[a]P EQs. As EPA has not established final remediation goals for the proposed ROD amendment, the results of these cPAH calculations are presented here for consideration without further comparison or discussion.

3.3 Exposure Barrier System and West Beach Sediments

The following two performance questions are applied to the collection of surface sediment samples on the EBS and West Beach, and measures of the EBS thickness:

1. Is the cap physically stable, remaining in place at a desired thickness?
2. Is the cap effectively isolating the underlying contaminated sediments?

The following section provides the results of the EBS and West Beach sediment sampling that can then be used to inform evaluation of these performance criteria.

3.3.1 Exposure Barrier System Physical Stability: Elevation Surveys

The individual components of the survey program, as outlined in the FSP, were conducted between January and May 2017. The results and conclusions based on the elevation surveys completed during Year 22 Monitoring are presented in a technical memorandum included as Appendix I

Collectively, the lines of evidence point to ongoing physical instability of the EBS cover material. Substantive erosion is shown in much of the EBS between post-construction (2008) and 2017. In some places, no cover was observed and the underlying cobble armor layer is exposed. The data suggest that erosion is ongoing and may not have stabilized. This conclusion is tempered however with considerable uncertainty relative to the comparability of the elevation survey data between the monitoring years, and by the fact that very limited direct-measurement data exists on EBS cover thickness.

3.3.2 Exposure Barrier System Physical Stability: Field Cover Measures

The locations and results of the EBS cover measures are shown in Figure 3-2 and Table 2-3. A minimum of 1 ft of fish habitat mix material is the relevant performance criterion. Nine locations within grids F11, H12, and I12 from the 2011 survey were reevaluated in 2017. Three discrete locations in the upper intertidal area of the EBS were evaluated based on the apparent exposure of the underlying cobble layer in the constructed EBS (location H12-c3). With only one exception, all of the targeted 2011 intertidal sampled stations reevaluated during this monitoring event were measured as having greater than the target 1 ft of habitat mix material thickness. The one exception, grid I12 (I12-e2), was measured at 0.95 ft. At the three high intertidal stations (sample locations H12-c3) no (i.e., 0 ft) overlying cover was identified.



3.3.3 Exposure Barrier System Chemical Isolation

Results of the chemical analyses for the EBS grid stations (i.e., F12, H12, H12c, and I12) relative to the SQS/MCUL are presented in Table 3-3 (sample locations shown in Figure 3-3). For all stations on the EBS, the PAH concentrations are low, or non-detect at the RL, and are below the SQS.

Table 3-4 compares the results of the EBS composite samples to the values designated in the ROD and the 2007 Explanation of Significant Differences (ESD) (EPA 2007). All intertidal surface sediments are also required to be protective of human health. The ROD for the EHOE established an intertidal sediment concentration for the protection of human health of a total HPAH concentration of 1.2 mg/kg dw. Criteria protective of human health were further defined in the 2007 ESD (EPA 2007) and are incorporated into the 2016 OMMP Addendum. Table 3-4 shows that all stations sampled on the EBS were below the associated human health criteria.

The calculated individual and total cPAH TEQ/B[a]P EQ concentrations are presented in Table 3-5. As EPA has not established final remediation goals for the proposed ROD amendment, the results of these cPAH calculations are presented here for considerations without further comparison or discussion.

3.3.4 Off-Exposure Barrier System Physical and Chemical Results

Two grid locations were sampled to the west of the EBS: D12 and E11. Grid D12 was a designated location in the FSP, while the sampling in grid E11 was determined in the field by Ecology (the discretionary west" sampling location). During collection at D11-c5, the smell of creosote was evident and sheens were noted in the hole left after sample collection. A photo of the sheen is included in the 13 January 2017 Daily Activity Report (Appendix E.2). Sheens were not reported at the other two discrete D11 sample stations. For the discretionary west location, sediment chemistry at the discrete west station E11-d4 west was collected close to old pilings. Creosote odor or sheens were not observed in any of the three discrete west sample locations.

Physical measurements were made with the driven sampling bar at the six discrete sampling sites near or within these two grids. These measurements are reported in Table 2-3; however, these measurements are not a measure of cover thickness, but represent depth-to-refusal at those locations. Sediment samples were collected within, or immediately proximal to grids D12 and E11. Specific sampling locations are shown in Figure 3-3.

Results of the chemical analyses for the off-EBS stations relative to the SQS are presented in Table 3-3 (sample locations shown in Figure 3-3). For the furthest west sample grid (D12), the TOC value is 0.39%; all chemicals of concern for that location are reported at concentrations below the LAET. For the grid E11 sample, the TOC was reported at 1.88% (2.8% in the replicate analysis); the measured concentrations were OC-normalized and compared to the SQS. The PAHs and PCP OC-normalized concentrations were all below the SQS.

Table 3-4 compares the results of the off-EBS composite samples to the human health remedial action goals designated in the ROD and the 2007 ESD (EPA 2007). The composite sample collected in grid D12 did not exceed any relevant criteria protective of

human health. However, the composite sample at grid E11 exceeded numerous individual compound-specific human health criteria and the ROD-established total HPAH concentration of 1.2 mg/kg dw. The exceedances for the off-EBS sample locations are presented in Figure 3-3.

The calculated individual and total cPAH TEQ/B[a]P EQ concentrations are presented in Table 3-5. As EPA has not established final remediation goals for the proposed ROD amendment, the results of these cPAH calculations are presented here for considerations without further comparison or discussion.

3.4 Clam Tissue Collection and Analysis

The reports providing the results of the 2014 and 2016 clam collection and tissue analysis conducted by the USACE is provided in Appendix D. This section provides excerpts of the results and conclusions provided in that report.

In the 2016 collection effort, horse clams were collected at the planned intertidal locations, including the East Beach, North Shoal, Intertidal Cap, and West Beach. To develop a background level of PAHs, horse clam tissue was also collected from Point No Point Park located on the northern end of the Kitsap Peninsula. On East Beach and the North Shoal, more *Tresus nuttallii* species clams were found, compared to the Intertidal Cap and West Beach, where primarily *Tresus capax* were found. The availability of clams on West Beach was significant as clams were not found there during the 2011 sampling program. Additional notes made during the collection included identifying a variety of marine organisms and birds during the low tides, including mussels, barnacles, moon snails, herons, and gulls.

Significant sheen and creosote was visibly noticeable on both sediment and shellfish on East Beach and North Shoal intertidal areas. The odor was strong and sheen/creosote was observed to 2 ft deep in the sediment. The shellfish at the site, particularly on East Beach, are still clearly in contact with creosote.

Table 3-6, as adapted from the USACE report in Appendix D, presents the 2016 clam tissue sample results from the four sections of the beach and the background location. PAHs were measured in all clam composites collected at the EHO intertidal areas. In contrast, only indeno(1,2,3-cd)pyrene was detected (at 4.78 µg/kg-w) in the single background clam sample collected (i.e., the sample collected off Point No Point Park). Total cPAHs⁷ for 2016 ranged from a high of 18.12 µg/kg-w at the East Beach sample location to a low of 9.97 µg/kg-w at the Intertidal Cap sample location.

Chemicals with consistently high concentrations at the 2016 locations included fluoranthene, phenanthrene, and pyrene. Average (arithmetic mean) concentrations for a given section of the beach for cPAHs were highest at the North Shoal sampling location, however this is only based on the single clam collected and analyzed. This concentration is higher than those at East Beach (average of 16.66 µg/kg-w), West Beach (average of 14.13 µg/kg-w), and the Intertidal Cap (average of 14.09 µg/kg-w).

⁷ Total cPAHs in the USACE report were summed using one-half the RL, where individual PAHs were reported as non-detected ("U").



The USACE's report also calculates for measured tissue concentrations of cPAHs using both the MTCA TEQ and the EPA (1993) B[a]P EQ.⁸ The following comparisons are made in Table 3-6:

- **cPAH.** The individual wet weight concentrations for sixteen PAHs, and the sum of the seven cPAHs. The sums are calculated at one-half the RL for non-detected values, and also assigning a value of 0 for non-detected compounds.
- **B[a]P Equivalents.** The individual wet weight concentrations for the seven cPAHs multiplied by the corresponding RPF. The resultant individual cPAH equivalents are then summed as B[a]P EQs using both one-half the RL value (times the RPF) and also assigning a value of 0 for non-detected compounds.
- **MTCA TEQ.** The individual wet weight concentrations for the seven cPAHs multiplied by the corresponding TEF. The resultant individual cPAH equivalents are then summed as a TEQ using both one-half the RL value (times the TEF) and also assigning a value of 0 for non-detected compounds.

Table 3-7 compares the analytical results from the 2011, 2014, and 2016 clam tissue collections, using the same comparisons as discussed for Table 3-6. The USACE reports that, in general, the B[a]P EQs calculated from the 2016 data were lower than those in 2011, but higher than 2014. The 2016 B[a]P EQs were generally higher than the 2014 B[a]P EQs at all sampling locations. In general, the B[a]P EQ values at the site do not have a definitive trend. B[a]P EQs have varied throughout the 2011, 2014, and 2016 sampling events, at all locations on the beach (West Beach, Intertidal Cap, North Shoal, and East Beach).

However, the OMMP identifies a concentration of 0.12 µg/kg B[a]P EQ/TEQ as a target concentration in clam tissue. Based on the results presented in Tables 3-6 and 3-7, all clam tissue B[a]P EQ/TEQ values, including the sample collected at the Point No Point background location, exceed this target clam tissue concentration.

⁸ The USACE 2016 report uses the term "potency equivalent factor" (PEF) to refer to benzo(a)pyrene TEQ of the individual cPAHs. PEF is a California-EPA term, not an EPA term (Elizabeth Allen, USEPA personal communication). EPA (1993) uses RPF for estimating the benzo(a)pyrene TEQ, and the sum of the cPAH RPF is referred to B[a]P EQ. The EPA nomenclature is used in this report.

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Table 3-1 - Subtidal Surface Sediment Monitoring Results Compared to the Sediment Management Standards

Quadrat Composite ID: Blind Sample ID: Collection Date:					Subtidal Surface Sediment Samples															
					J7	J8	J8	J9	J9	J9	J9	J10	J10	K7	K7	K8	K8	L8	L8	
					12317001	12317003	12317003	12417002	12417002	12417003 (Replicate)	12417003 (Replicate)	12417004	12417004	12317002	12317002	12317004	12317004	12417001	12417001	
					1/23/2017	1/23/2017	1/23/2017	1/24/2017	1/24/2017	1/24/2017	1/24/2017	1/24/2017	1/24/2017	1/23/2017	1/23/2017	1/23/2017	1/23/2017	1/24/2017	1/24/2017	
Conventionals																				
Total Solids (%)	-	-	-	-	79.9	70.89	70.89	69.37	69.37	67.78	67.78	68.46	68.46	77.67	77.67	77.47	77.47	65.66	65.66	
Total Organic Carbon (%)	-	-	-	-	0.48	0.55	0.55	1.52	J	1.52	J	1.98	J	1.98	J	1.54	1.54	0.68	0.68	
Grain Size																				
Total Gravel (Phi Size < -1) (%)	-	-	-	-	16.8	1	1	29.3	29.3	29	29	30.4	30.4	9.8	9.8	4.8	4.8	1.9	1.9	
Total Sand (Phi -1 to 4) (%)	-	-	-	-	76.4	87.3	87.3	48	48	47.7	47.7	47.2	47.2	77.4	77.4	84.6	84.6	76.2	76.2	
Total Silt (Phi Size 4 to 8) (%)	-	-	-	-	4.8	8.1	8.1	16.4	16.4	17.2	17.2	15.5	15.5	9	9	8.5	8.5	17.4	17.4	
Total Clay (Phi Size >8) (%)	-	-	-	-	1.9	3.7	3.7	6.2	6.2	6	6	7	7	3.8	3.8	2.1	2.1	4.5	4.5	
Total Fines (Phi Size >4) (%)	-	-	-	-	6.8	J	11.7	J	11.7	J	23.2	J	23.2	J	22.5	J	12.8	J	12.8	J
PAHs	LAET (µg/kg dw)	2LAET (µg/kg dw)	SQS (mg/kg OC)	MCUL (mg/kg OC)	µg/kg dw	µg/kg dw	mg/kg OC	µg/kg dw	mg/kg OC	µg/kg dw	mg/kg OC	µg/kg dw	mg/kg OC	µg/kg dw	mg/kg OC	µg/kg dw	mg/kg OC	µg/kg dw	mg/kg OC	
Naphthalene	2,100	2,100	99	170	51.6	25.3	4.6	95.9	6.31	94.3	4.76	44.7	J	2.9	J	45.8	6.74	194	28.96	
2-Methylnaphthalene	670	670	38	64	18.6	11.7	2.13	30.7	2.02	31	1.57	20.6	J	1.34	J	17.9	2.63	64.8	9.67	
1-Methylnaphthalene	--	--	--	--	15.3	7.1	1.29	19.2	1.26	20	1.01	11.2	J	0.73	J	10.7	1.57	41.5	6.19	
Acenaphthylene	1,300	1,300	66	66	4.87	U	8.9	1.62	52.3	3.44	51.7	2.61	14.2	0.92	11.9	1.75	15.1	2.25	34	5.15
Acenaphthene	500	500	16	57	34.3	16.6	3.02	38.1	2.51	39.1	1.97	19.7	1.28	23.9	3.51	118	17.61	206	31.21	
Fluorene	540	540	23	79	29.2	J	23.2	J	4.22	J	64.4	J	4.24	J	69.1	J	3.49	J	32.2	J
Phenanthrene	1,500	1,500	100	480	61.7	83.7	15.22	228	15	267	13.48	99.3	J	6.45	J	112	16.47	322	48.06	
Anthracene	960	960	220	1,200	66.6	J	50.9	J	9.25	J	279	J	18.36	J	777	J	39.24	J	148	J
LPAH	5,200	5,200	370	780	209.1	192	34.9	719.6	47.4	1259.1	63.6	338.4	22	281.6	41.4	795.1	118.7	1650	250	
Fluoranthene	1,700	2,500	160	1,200	88.7	J	154	J	28	J	588	J	38.68	J	966	J	48.79	J	205	J
Pyrene	2,600	3,300	1,000	1,400	81.3	J	148	J	26.91	J	1760	J	115.79	J	2030	J	102.53	J	339	J
Benzo(a)anthracene	1,300	1,600	110	270	48.3	J	74.8	J	13.6	J	712	J	46.84	J	972	J	49.09	J	117	J
Chrysene	1,400	2,800	110	460	65.8	102	18.55	1080	71.05	1360	68.69	183	J	11.88	J	118	17.35	218	32.54	
Total Benzofluoranthenes	3,200	3,600	230	450	68.4	178	32.36	1420	93.42	1780	89.9	333	J	21.62	J	209	30.74	303	45.22	
Benzo(a)pyrene	1,600	1,600	99	210	26.5	68.3	12.42	572	37.63	630	31.82	122	7.92	83.2	12.24	104	15.52	235	35.61	
Indeno(1,2,3-cd)pyrene	600	690	34	88	11.8	34.2	6.22	217	14.28	222	11.21	58.2	3.78	35.8	5.26	44.6	6.66	113	17.12	
Dibenz(a,h)anthracene	230	230	12	33	4.87	U	9.56	1.74	80.9	5.32	84.1	4.25	19.6	1.27	11.4	1.68	16	2.39	37.5	5.68
Benzo(g,h,i)perylene	670	720	31	78	10.7	35.3	6.42	212	13.95	208	10.51	60.8	3.95	37.8	5.56	46.3	6.91	118	17.88	
HPAH	12,000	17,000	960	5,300	401.5	804.2	146.2	6641.9	437	8252.1	416.8	1437.6	93.3	949.2	139.6	1718.9	256.6	3565.5	540.2	
Other Constituents																				
Pentachlorophenol	360	690	360	690	7.34	U	26.8	J	4.87	J	9	U	0.59	U	9.07	U	0.46	U	9.07	U
Inorganics	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	
Mercury	0.41	0.59	0.41	0.59	0.05709	0.07083	0.07083	0.1076	0.1076	0.09953	0.09953	0.131	J	0.131	J	0.0769	0.0769	0.06885	0.06885	

U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated
UJ = Analyte not detected above the reporting limit; reporting limit considered approximate
N/A = not analyzed
-- = No criterion available

LPAH = Low Molecular Weight Polycyclic Aromatic Hydrocarbons (Naphthalene, Acenaphthylene, Fluorene, Phenanthrene, and Anthracene). Only detected concentrations summed into LPAH total
HPAH = High Molecular Weight Polycyclic Aromatic Hydrocarbons (Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Total Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(a,h)anthracene, and Benzo(g,h,i)perylene). Only detected concentrations summed into HPAH total.

µg/kg dw = micrograms/kilogram dry weight
mg/kg OC = milligrams/kilograms organic carbon normalized
2LAET = Second Lower Apparent Threshold Effects
LAET = Lower Apparent Threshold Effects
SQS = Sediment Quality Standard
MCUL = Minimum Cleanup Level

Samples with total organic carbon between 0.5% and 3.5%, the results were compared to SQS and MCUL. Others were compared to LAET and 2LAET
Organic Carbon Normalized results (mg/kg OC) were calculated in accordance with *Organic Carbon Normalization of Sediment Data* (Washington State Department of Ecology [Ecology] 1992).
Gray shading indicates exceedance of one or more criteria. **Bold, black text exceeds either SQS or LAET (based on TOC%)**
Total benzofluoranthene concentrations (b, j, and k isomers) as reported by the laboratory.

Table 3-2 - Subtidal Surface Sediment Monitoring Results - Carcinogenic Polycyclic Aromatic Hydrocarbon (cPAH) Toxicity Equivalence (TEQ) and Benzo(a)pyrene (B[a]P) Equivalence

			Subtidal Surface Sediment Samples														
			J7 12317001 1/23/2017			J8 12317003 1/23/2017			J9 12417002 1/24/2017			J9 12417003 (Replicate) 1/24/2017			J10 12417004 1/24/2017		
cPAHs	TEF (unitless)	RPF (unitless)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)
Benzo(a)anthracene	0.1	0.1	48.3 J	4.83	4.83	74.8 J	7.48	7.48	712	71.2	71.2	972 J	97.2	97.2	117 J	11.7	11.7
Chrysene	0.01	0.001	65.8	0.658	0.066	102	1.02	0.102	1080	10.8	1.08	1360	13.6	1.36	183 J	1.83	0.183
Benzo(b)fluoranthene	0.1	0.1	33.9	3.39	3.39	95.8	9.58	9.58	842	84.2	84.2	939	93.9	93.9	179	17.9	17.9
Benzo(k)fluoranthene	0.1	0.01	19.1	1.91	0.191	44.3	4.43	0.443	354	35.4	3.54	396	39.6	3.96	85.3	8.53	0.853
Benzo(a)pyrene	1	1	26.5	26.5	26.5	68.3	68.3	68.3	572	572	572	630	630	630	122	122	122
Indeno(1,2,3-cd)pyrene	0.1	0.1	11.8	1.18	1.18	34.2	3.42	3.42	217	21.7	21.7	222	22.2	22.2	58.2	5.82	5.82
Dibenz(a,h)anthracene	0.1	1	4.87 U	0.2435	2.435	9.56	0.956	9.56	80.9	8.09	80.9	84.1	8.41	84.1	19.6	1.96	19.6
				TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)
Total cPAH (ND at 0.5*RL):				38.71	38.59		95.19	98.89		803.39	834.62		904.91	932.7		169.74	178.06

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated
UJ = Analyte not detected above the reporting limit; reporting limit considered approximate

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
ND = non-detect
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = relative potency factor (EPA 1993)

Table 3-2 - Subtidal Surface Sediment Monitoring Results - Carcinogenic Polycyclic Aromatic Hydrocarbon (cPAH) Toxicity Equivalence (TEQ) and Benzo(a)pyrene (B[a]P) Equivalence

			Subtidal Surface Sediment Samples								
			K7 12317002 1/23/2017			K8 12317004 1/23/2017			L8 12417001 1/24/2017		
cPAHs	TEF (unitless)	RPF (unitless)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	ug/kg dw	TEQ (ug/kg)	B[a]P EQ (µg/kg)
Benzo(a)anthracene	0.1	0.1	96 J	9.6	9.6	129 J	12.9	12.9	269 J	26.9	26.9
Chrysene	0.01	0.001	118	1.18	0.118	218	2.18	0.218	323	3.23	0.323
Benzo(b)fluoranthene	0.1	0.1	111	11.1	11.1	155	15.5	15.5	369	36.9	36.9
Benzo(k)fluoranthene	0.1	0.01	52.2	5.22	0.522	80.1	8.01	0.801	168	16.8	1.68
Benzo(a)pyrene	1	1	83.2	83.2	83.2	104	104	104	235	235	235
Indeno(1,2,3-cd)pyrene	0.1	0.1	35.8	3.58	3.58	44.6	4.46	4.46	113	11.3	11.3
Dibenz(a,h)anthracene	0.1	1	11.4	1.14	11.4	16	1.6	16	37.5	3.75	37.5
				TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)
Total cPAH (ND at 0.5*RL):				115.02	119.5		148.65	153.9		333.88	349.6

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated
UJ = Analyte not detected above the reporting limit; reporting limit considered approximate

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
ND = non-detect
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = relative potency factor (EPA 1993)

Table 3-3 - Exposure Barrier System Sediment Monitoring Results Compared to the Sediment Management Standards

Quadrat Composite ID: Blind Sample ID: Collection Date:					Off-Exposure Barrier System Samples					Exposure Barrier System Samples				
					D12	E11-d4	E11-d4	E11-d4	E11-d4	F12	H12	H12-c3	I12	
					11317001	11317006 (Discretionary West)	11317006 (Discretionary West)	11317007 (Replicate)	11317007 (Replicate)	11317002	11317003	11317005 (Discretionary East)	11317004	
					1/13/2017	1/14/2017	1/14/2017	1/14/2017	1/14/2017	1/13/2017	1/13/2017	1/14/2017	1/14/2017	
Conventionals														
Total Solids (%)	-	-	-	-	83.51	84.86	84.86	83.5	83.5	96.53	94.03	74.26	94.13	
Total Organic Carbon (%)	-	-	-	-	0.39	1.88 J	1.88 J	2.8 J	2.8 J	0.13	0.08	0.09	0.09	
Grain Size														
Total Gravel (Phi Size < -1) (%)	-	-	-	-	30.5	43.4	43.4	41.8	41.8	27.5	14.6	66	20.5	
Total Sand (Phi -1 to 4) (%)	-	-	-	-	61.3	48.6	48.6	52.8	52.8	71.4	85.2	32.9	79	
Total Silt (Phi Size 4 to 8) (%)	-	-	-	-	4.6	5.5	5.5	3.2	3.2	1.1	0.2	1.2	0.5	
Total Clay (Phi Size >8) (%)	-	-	-	-	3.5	2.4	2.4	2.2	2.2	0	0	0	0	
Total Fines (Phi Size >4) (%)	-	-	-	-	8.1 J	7.9 J	7.9 J	5.5 J	5.5 J	1.1	0.2	1.2	0.5	
PAHs	LAET (µg/kg dw)	2LAET (µg/kg dw)	SQS (mg/kg OC)	MCUL (mg/kg OC)	µg/kg dw	µg/kg dw	mg/kg OC	µg/kg dw	mg/kg OC	µg/kg dw	µg/kg dw	µg/kg dw	µg/kg dw	
Naphthalene	2,100	2,100	99	170	4.73 U	29.9 J	1.59 J	18.7 J	0.67 J	32.4	4.71 U	4.67 U	4.71 U	
2-Methylnaphthalene	670	670	38	64	4.73 U	9.88 J	0.53 J	15.3 J	0.55 J	6.77	4.71 U	4.67 U	4.71 U	
1-Methylnaphthalene	--	--	--	--	4.73 U	6.54	0.35	10.5	0.38	4.71 U	4.71 U	4.67 U	4.71 U	
Acenaphthylene	1,300	1,300	66	66	4.73 U	15.1	0.8	11.9	0.43	4.71 U	4.71 U	4.67 U	4.71 U	
Acenaphthene	500	500	16	57	4.73 U	13.1 J	0.7 J	11.2	0.4	4.71 U	4.71 U	4.67 U	4.71 U	
Fluorene	540	540	23	79	4.73 U	16.8 J	0.89 J	15.8 J	0.56 J	4.71 UJ	4.71 UJ	4.67 UJ	4.71 UJ	
Phenanthrene	1,500	1,500	100	480	14.2 J	71 J	3.78 J	53.1 J	1.9 J	14.5 J	4.71 U	7.71 J	4.71 UJ	
Anthracene	960	960	220	1,200	10.2 J	60.9 J	3.24 J	53.2 J	1.9 J	4.71 U	4.71 UJ	4.67 U	4.71 UJ	
LPAH	5,200	5,200	370	780	24.4	193.7	10.3	152.7	5.5	51.6	9.4	12.4	14.1	
Fluoranthene	1,700	2,500	160	1,200	70.1	677 J	36.01 J	486 J	17.36 J	12.5	4.71 U	8.35 J	4.71 U	
Pyrene	2,600	3,300	1,000	1,400	60.4 J	699 J	37.18 J	643 J	22.96 J	9.72 J	4.71 U	9.38 J	4.71 U	
Benzo(a)anthracene	1,300	1,600	110	270	23 J	142 J	7.55 J	145 J	5.18 J	4.71 U	4.71 UJ	4.67 U	4.71 UJ	
Chrysene	1,400	2,800	110	460	30.9	299 J	15.9 J	229	8.18	8.04	4.71 U	4.67 U	4.71 U	
Total Benzofluoranthenes	3,200	3,600	230	450	61	465 J	24.73 J	379	13.54	9.43 U	9.42 U	9.34 U	9.41 U	
Benzo(a)pyrene	1,600	1,600	99	210	21.1	146 J	7.77 J	120	4.29	4.71 U	4.71 U	4.67 U	4.71 U	
Indeno(1,2,3-cd)pyrene	600	690	34	88	11	64.2 J	3.41 J	47.7	1.7	4.71 U	4.71 U	4.67 U	4.71 U	
Dibenz(a,h)anthracene	230	230	12	33	4.73 U	19.5 J	1.04 J	17 J	0.61 J	4.71 UJ	4.71 UJ	4.67 UJ	4.71 UJ	
Benzo(g,h,i)perylene	670	720	31	78	12.2	63.4 J	3.37 J	47.1	1.68	4.71 U	4.71 U	4.67 U	4.71 U	
HPAH	12,000	17,000	960	5,300	289.7	2575.1	137	2113.8	75.5	35	9.4	22.4	9.4	
Other Constituents														
Pentachlorophenol	360	690	360	690	7.17 U	15.3 J	0.81 J	8.8 J	0.31 J	6.45 U	6.53 U	6.49 U	6.52 U	

U = Analyte not detected at the reporting limit

J = Analyte detected above the reporting limit; concentration estimated

UJ = Analyte not detected above the reporting limit; reporting limit considered approximate.

N/A = not analyzed

-- = No criterion available

LPAH = Low Molecular Weight Polycyclic Aromatic Hydrocarbons (Naphthalene, Acenaphthylene, Fluorene, Phenanthrene, and Anthracene). Only detected concentrations summed into LPAH total.

HPAH = High Molecular Weight Polycyclic Aromatic Hydrocarbons (Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Total Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(a,h)anthracene, and Benzo(g,h,i)perylene). Only detected concentrations summed into HPAH total.

µg/kg dw = micrograms/kilogram dry weight

mg/kg OC = milligrams/kilograms organic carbon normalized

2LAET = Second Lower Apparent Threshold Effects

LAET = Lower Apparent Threshold Effects

SQS = Sediment Quality Standard

MCUL = Minimum Cleanup Level

Samples with total organic carbon between 0.5% and 3.5%, the results were compared to SQS and MCUL. Others were compared to LAET and 2LAET.

Organic Carbon Normalized results (mg/kg OC) were calculated in accordance with *Organic Carbon Normalization of Sediment Data* (Washington State Department of Ecology [Ecology] 1992).

Gray shading indicates exceedance of one or more criteria. **Bold, black text exceeds either SQS or LAET (based on TOC%)**

Total benzofluoranthene concentrations (b, j, and k isomers) as reported by the laboratory.

Table 3-4 - Exposure Barrier System Sediment Monitoring Results Compared to Human Health Remedial Action Goals

				Off-Exposure Barrier System Samples			Exposure Barrier System Samples			
Quadrant Composite ID:				D12	E11-d4	E11-d4	F12	H12	H12-c3	I12
Blind Sample ID:				11317001	11317006 (Discretionary West)	11317007 (Replicate)	11317002	11317003	11317005 (Discretionary East)	11317004
Collection Date:				1/13/2017	1/14/2017	1/14/2017	1/13/2017	1/13/2017	1/14/2017	1/14/2017
Conventionals										
Total Solids (%)	-	-	-	83.51	84.86	83.5	96.53	94.03	74.26	94.13
Total Organic Carbon (%)	-	-	-	0.39	1.88 J	2.8 J	0.13	0.08	0.09	0.09
Grain Size										
Total Gravel (Phi Size < -1) (%)	-	-	-	30.5	43.4	41.8	27.5	14.6	66	20.5
Total Sand (Phi -1 to 4) (%)	-	-	-	61.3	48.6	52.8	71.4	85.2	32.9	79
Total Silt (Phi Size 4 to 8) (%)	-	-	-	4.6	5.5	3.2	1.1	0.2	1.2	0.5
Total Clay (Phi Size >8) (%)	-	-	-	3.5	2.4	2.2	0	0	0	0
Total Fines (Phi Size >4) (%)	-	-	-	8.1 J	7.9 J	5.5 J	1.1	0.2	1.2	0.5
PAHs	Intertidal Sediment Method B Carcinogen - Unrestricted Land Use (µg/kg dw)	Intertidal Sediment Method B Non-Carcinogen - Unrestricted Land Use (µg/kg dw)	ROD Intertidal Sediment Human Health (µg/kg dw)	µg/kg dw	µg/kg dw	µg/kg dw	µg/kg dw	µg/kg dw	µg/kg dw	µg/kg dw
Naphthalene	-	1,600,000	-	4.73 U	29.9 J	18.7 J	32.4	4.71 U	4.67 U	4.71 U
2-Methylnaphthalene	-	320,000	-	4.73 U	9.88 J	15.3 J	6.77	4.71 U	4.67 U	4.71 U
1-Methylnaphthalene	-	24,000	-	4.73 U	6.54	10.5	4.71 U	4.71 U	4.67 U	4.71 U
Acenaphthylene	-	-	-	4.73 U	15.1	11.9	4.71 U	4.71 U	4.67 U	4.71 U
Acenaphthene	-	4,800,000	-	4.73 U	13.1 J	11.2	4.71 U	4.71 U	4.67 U	4.71 U
Fluorene	-	3,200,000	-	4.73 U	16.8 J	15.8 J	4.71 UJ	4.71 UJ	4.67 UJ	4.71 UJ
Phenanthrene	-	-	-	14.2 J	71 J	53.1 J	14.5 J	4.71 U	7.71 J	4.71 UJ
Anthracene	-	24,000,000	-	10.2 J	60.9 J	53.2 J	4.71 U	4.71 UJ	4.67 U	4.71 UJ
LPAH	-	-	-	24.4	193.7	152.7	51.6	9.4	12.4	14.1
Fluoranthene	-	3,200,000	-	70.1	677 J	486 J	12.5	4.71 U	8.35 J	4.71 U
Pyrene	-	2,400,000	-	60.4 J	699 J	643 J	9.72 J	4.71 U	9.38 J	4.71 U
Benzo(a)anthracene	140	-	-	23 J	142 J	145 J	4.71 U	4.71 UJ	4.67 U	4.71 UJ
Chrysene	140	-	-	30.9	299 J	229	8.04	4.71 U	4.67 U	4.71 U
Benzo(b)fluoranthene	140	-	-	31.3	238 J	195	4.71 U	4.71 U	5.85 J	4.71 U
Benzo(k)fluoranthene	140	-	-	14.6	117 J	94.1	4.71 U	4.71 U	4.67 U	4.71 U
Benzo(a)pyrene	140	-	-	21.1	146 J	120	4.71 U	4.71 U	4.67 U	4.71 U
Indeno(1,2,3-cd)pyrene	140	-	-	11	64.2 J	47.7	4.71 U	4.71 U	4.67 U	4.71 U
Dibenz(a,h)anthracene	140	-	-	4.73 U	19.5 J	17 J	4.71 UJ	4.71 UJ	4.67 UJ	4.71 UJ
Benzo(g,h,i)perylene	-	-	-	12.2	63.4 J	47.1	4.71 U	4.71 U	4.67 U	4.71 U
HPAH	-	-	1,200	289.7	2575.1	2113.8	35	9.4	22.4	9.4
Total PAHs	1,400	-	-	314.1	2768.8	2266.5	86.6	18.8	34.8	23.5
Other Constituents										
Pentachlorophenol	8,300	-	-	7.17 U	15.3 J	8.8 J	6.45 U	6.53 U	6.49 U	6.52 U

Note: The intertidal sediment Method B non-carcinogen unrestricted land use value for naphthalene published in the Explanation of Significant Differences and the 2016 Operation, Maintenance, and Monitoring Plan (OMMP) is incorrect. The value was recalculated by the US Army Corps of Engineers and the US Environmental Protection Agency for the 2011 monitoring program. The 2004 Model Toxics Control Act value is 1,600,000 µg/kg; this value was used in the 2011 OMMP, the 2012 Monitoring Report, and in this documentation.

U = Analyte not detected at the reporting limit

J = Analyte detected above the reporting limit; concentration estimated

UJ = Analyte not detected above the reporting limit; reporting limit considered approximate.

LPAH = Low Molecular Weight Polycyclic Aromatic Hydrocarbons (Naphthalene, Acenaphthylene, Fluorene, Phenanthrene, and Anthracene). Only detected concentrations summed into LPAH total

HPAH = High Molecular Weight Polycyclic Aromatic Hydrocarbons (Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Total Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenz(a,h)anthracene, and

Benzo(g,h,i)perylene). Only detected concentrations summed into HPAH total.

Shading with **bold** text indicates exceedance of criteria.

µg/kg dw = micrograms/kilogram dry weight

Table 3-5 - Exposure Barrier System Sediment Monitoring Results - Carcinogenic Polycyclic Aromatic Hydrocarbon (cPAH) Toxicity Equivalence (TEQ) and Benzo(a)Pyrene B[a]P Equivalence

			West Beach Samples								
			D12 11317001 1/13/2017			E11-d4 11317006 (Discretionary West) 1/14/2017			E-11 (Replicate) 11317007 (Replicate) 1/14/2017		
cPAHs	TEF (unitless)	RPF (unitless)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)
Benzo(a)anthracene	0.1	0.1	23 J	2.3	2.3	142 J	14.2	14.2	145 J	14.5	14.5
Chrysene	0.01	0.001	30.9	0.309	0.0309	299 J	2.99	0.299	229	2.29	0.229
Benzo(b)fluoranthene	0.1	0.1	31.3	3.13	3.13	238 J	23.8	23.8	195	19.5	19.5
Benzo(k)fluoranthene	0.1	0.01	14.6	1.46	0.146	117 J	11.7	1.17	94.1	9.41	0.941
Benzo(a)pyrene	1	1	21.1	21.1	21.1	146 J	146	146	120	120	120
Indeno(1,2,3-cd)pyrene	0.1	0.1	11	1.1	1.1	64.2 J	6.42	6.42	47.7	4.77	4.77
Dibenz(a,h)anthracene	0.1	1	4.73 U	0.2365	2.365	19.5 J	1.95	19.5	17 J	1.7	17
				TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)
Total cPAH (ND at 0.5*RL):				29.64	30.17		207.06	211.39		172.17	176.94

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated
UJ = Analyte not detected above the reporting limit; reporting limit considered approximate

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
ND = non-detect
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = relative potency factor (EPA 1993)

Table 3-5 - Exposure Barrier System Sediment Monitoring Results - Carcinogenic Polycyclic Aromatic Hydrocarbon (cPAH) Toxicity Equivalence (TEQ) and Benzo(a)Pyrene B[a]P Equivalence

			Exposure Barrier System Samples											
			F12 11317002 1/13/2017			H12 11317003 1/13/2017			H12-c3 11317005 (Discretionary East) 1/14/2017			I12 11317004 1/14/2017		
cPAHs	TEF (unitless)	RPF (unitless)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)	µg/kg dw	TEQ (µg/kg)	B[a]P EQ (µg/kg)
Benzo(a)anthracene	0.1	0.1	4.71 U	0.2355	0.2355	4.71 UJ	0.2355	0.2355	4.67 U	0.2335	0.2335	4.71 UJ	0.2355	0.2355
Chrysene	0.01	0.001	8.04	0.0804	0.00804	4.71 U	0.02355	0.002355	4.67 U	0.02335	0.002335	4.71 U	0.02355	0.002355
Benzo(b)fluoranthene	0.1	0.1	4.71 U	0.2355	0.2355	4.71 U	0.2355	0.2355	5.85 J	0.585	0.585	4.71 U	0.2355	0.2355
Benzo(k)fluoranthene	0.1	0.01	4.71 U	0.2355	0.02355	4.71 U	0.2355	0.02355	4.67 U	0.2335	0.02335	4.71 U	0.2355	0.02355
Benzo(a)pyrene	1	1	4.71 U	2.355	2.355	4.71 U	2.355	2.355	4.67 U	2.335	2.335	4.71 U	2.355	2.355
Indeno(1,2,3-cd)pyrene	0.1	0.1	4.71 U	0.2355	0.2355	4.71 U	0.2355	0.2355	4.67 U	0.2335	0.2335	4.71 U	0.2355	0.2355
Dibenz(a,h)anthracene	0.1	1	4.71 UJ	0.2355	2.355	4.71 UJ	0.2355	2.355	4.67 UJ	0.2335	2.335	4.71 UJ	0.2355	2.355
				TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)		TEQ (µg/kg)	B[a]P EQ (µg/kg)
Total cPAH (ND at 0.5*RL):				3.61	5.45		3.56	5.44		3.88	5.75		3.56	5.44

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated
UJ = Analyte not detected above the reporting limit; reporting limit considered approximate

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
ND = non-detect
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = relative potency factor (EPA 1993)

Table 3.6 - 2016 Clam Tissue Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			EAST BEACH # 1				EAST BEACH # 2				EAST BEACH #3			
Compound	EPA B[a]P Relative Potency Factor (RPF)	MTCA B[a]P Toxicity Equivalency Factor (TEF)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			2.30				2.70				3.40			
Acenaphthene			2.10				2.70				3.00			
Acenaphthylene			0.77	U			0.74	U			0.75	U		
Anthracene			3.00				3.10				4.20			
Benzo(a)anthracene	0.10	0.10	3.40		0.34	0.34	4.60	J	0.46	0.46	5.60	J	0.56	0.56
Benzo(a)pyrene	1.00	1.00	0.98		0.98	0.98	0.85		0.85	0.85	0.98		0.98	0.98
Benzo(g,h,i)perylene			1.30				0.74	U			0.75	U		
Benzo[b]Fluoranthene	0.10	0.10	3.40		0.34	0.34	3.30		0.33	0.33	4.80		0.48	0.48
Benzo[k]fluoranthene	0.01	0.10	1.00		0.0100	0.10	0.79		0.0079	0.08	0.99		0.0099	0.10
Chrysene	0.001	0.01	3.50		0.0035	0.04	4.20		0.0042	0.04	5.00		0.0050	0.05
Dibenzo[a,h]anthracene	1.00	0.10	0.77	U	0.39	0.04	0.74	U	0.37	0.04	0.75	U	0.38	0.04
Fluoranthene			17.00				22.00				22.00			
Indeno(1,2,3-cd)pyrene	0.10	0.10	5.20		0.52	0.52	1.20	J	0.12	0.12	0.75	U	0.04	0.04
Naphthalene			2.60	U			2.10	U			2.60	U		
Naphthalene, 1-methyl-			1.10				0.97				1.50			
Naphthalene, 2-methyl-			2.30	U			1.90	U			2.30	U		
Phenanthrene			12.00				18.00				16.00			
Pyrene			14.00				21.00				27.00			
Lipids%			0.49				0.53				0.56			
Total cPAH (ND = 0.5 *RL)			17.87				15.31				18.12			
Total cPAH (ND = 0)			17.48				14.94				17.37			
Total EPA B[a]P EQ (ND = 0.5 * RL)					2.58				2.14				2.45	
Total EPA B[a]P EQ (ND = 0)					2.19				1.77				2.03	
Total MTCA TEQ (ND = 0.5 *RL)						2.35				1.92				2.24
Total MTCA TEQ (ND = 0)						2.32				1.88				2.17

Analytical Results Notes:

- U = Analyte not detected at the reporting limit
- J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:

For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.

B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]

cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon

EPA = US Environmental Protection Agency

FD = field duplicate

MTCA = Model Toxics Control Act

ND = non-detect

µg/kg-w = micrograms per kilogram wet weight

TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)

TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]

RL = reporting limit

RPF = Relative Potency Factor (EPA 1993)

Table 3.6 - 2016 Clam Tissue Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			East Beach #3 (FD)				INTERDIAL CAP #1				INTERTIDAL CAP # 2			
Compound	EPA B[a]P Relative Potency Factor (RPF)	MTCA B[a]P Toxicity Equivalency Factor (TEF)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			2.70				2.70				2.40			
Acenaphthene			2.50				2.30				2.00			
Acenaphthylene			0.77	U			0.76	U			0.75	U		
Anthracene			3.30				3.50				2.90			
Benzo(a)anthracene	0.10	0.10	3.90		0.39	0.39	3.50		0.35	0.35	3.30		0.33	0.33
Benzo(a)pyrene	1.00	1.00	0.77	U	0.39	0.39	0.76	U	0.38	0.38	0.75	U	0.38	0.38
Benzo(g,h,i)perylene			0.77	U			0.76	U			0.75	U		
Benzo[b]Fluoranthene	0.10	0.10	3.00		0.30	0.30	4.60		0.46	0.46	3.80		0.38	0.38
Benzo[k]fluoranthene	0.01	0.10	0.77	U	0.0039	0.04	0.81		0.01	0.08	0.80		0.0080	0.08
Chrysene	0.001	0.01	3.30		0.0033	0.03	3.70		0.00	0.04	3.20		0.0032	0.03
Dibenzo[a,h]anthracene	1.00	0.10	0.77	U	0.39	0.04	0.76	U	0.38	0.04	0.75	U	0.38	0.04
Fluoranthene			17.00				19.00				15.00			
Indeno(1,2,3-cd)pyrene	0.10	0.10	4.00		0.40	0.40	3.30		0.33	0.33	4.00		0.40	0.40
Naphthalene			2.70	U			2.40	U			2.50	U		
Naphthalene, 1-methyl-			1.40				0.86				0.87			
Naphthalene, 2-methyl-			2.10	U			2.00	U			1.80	U		
Phenanthrene			15.00				14.00				12.00			
Pyrene			16.00				15.00				12.00			
Lipids%			0.31				0.56				0.49			
Total cPAH (ND = 0.5 *RL)			15.36				16.67				15.85			
Total cPAH (ND = 0)			14.20				15.91				15.10			
Total EPA B[a]P EQ (ND = 0.5 * RL)					1.87				1.91				1.87	
Total EPA B[a]P EQ (ND = 0)					1.09				1.15				1.12	
Total MTCA TEQ (ND = 0.5 *RL)						1.59				1.68				1.63
Total MTCA TEQ (ND = 0)						1.12				1.26				1.22

Analytical Results Notes:

- U = Analyte not detected at the reporting limit
- J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:

For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.

B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]

cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon

EPA = US Environmental Protection Agency

FD = field duplicate

MTCA = Model Toxics Control Act

ND = non-detect

µg/kg-w = micrograms per kilogram wet weight

TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)

TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]

RL = reporting limit

RPF = Relative Potency Factor (EPA 1993)

Table 3.6 - 2016 Clam Tissue Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			INTERTIDAL CAP # 3				Intertidal Cap #2 (FD)				NORTH SHOAL # 1			
Compound	EPA B[a]P Relative Potency Factor (RPF)	MTCA B[a]P Toxicity Equivalency Factor (TEF)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.20				1.90				3.70			
Acenaphthene			0.98				1.70				3.10			
Acenaphthylene			0.78	U			0.78	U			0.75	U		
Anthracene			1.80				2.50				3.40			
Benzo(a)anthracene	0.10	0.10	1.70		0.17	0.17	2.60		0.26	0.26	4.30		0.43	0.43
Benzo(a)pyrene	1.00	1.00	0.78	U	0.39	0.39	0.78	U	0.39	0.39	0.99		0.99	0.99
Benzo(g,h,i)perylene			0.78	U			0.78	U			0.75	U		
Benzo[b]Fluoranthene	0.10	0.10	2.00		0.20	0.20	4.10		0.41	0.41	4.90		0.49	0.49
Benzo[k]fluoranthene	0.01	0.10	0.78	U	0.0039	0.04	0.78	U	0.0039	0.04	1.00		0.0100	0.10
Chrysene	0.001	0.01	1.70		0.0017	0.02	2.70		0.0027	0.03	5.00		0.0050	0.05
Dibenzo[a,h]anthracene	1.00	0.10	0.78	U	0.39	0.04	0.78	U	0.39	0.04	0.75	U	0.38	0.08
Fluoranthene			8.70				14.00				26.00			
Indeno(1,2,3-cd)pyrene	0.10	0.10	3.40		0.34	0.34	3.30		0.33	0.33	0.75	U	0.04	0.08
Naphthalene			1.70	U			2.30	U			2.80	U		
Naphthalene, 1-methyl-			0.78	U			0.78	U			1.30			
Naphthalene, 2-methyl-			1.20	U			1.70	U			2.30	U		
Phenanthrene			5.50				9.30				20.00			
Pyrene			6.90				11.00				27.00			
Lipids%			0.49				0.41				0.57			
Total cPAH (ND = 0.5 *RL)			9.97				13.87				16.94			
Total cPAH (ND = 0)			8.80				12.70				16.19			
Total EPA B[a]P EQ (ND = 0.5 * RL)					1.50				1.79				2.34	
Total EPA B[a]P EQ (ND = 0)					0.71				1.00				1.93	
Total MTCA TEQ (ND = 0.5 *RL)						1.20				1.50				2.21
Total MTCA TEQ (ND = 0)						0.73				1.03				2.06

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3.6 - 2016 Clam Tissue Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			West Beach #1				West Beach #2				West Beach #3			
Compound	EPA B[a]P Relative Potency Factor (RPF)	MTCA B[a]P Toxicity Equivalency Factor (TEF)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			2.20				3.10				2.30			
Acenaphthene			1.90				3.30				1.90			
Acenaphthylene			0.77	U			0.76	U			0.77	U		
Anthracene			2.30				3.00				2.10			
Benzo(a)anthracene	0.10	0.10	2.70		0.27	0.27	2.80		0.28	0.28	2.40		0.24	0.24
Benzo(a)pyrene	1.00	1.00	0.77	U	0.39	0.39	0.76	U	0.38	0.38	0.77	U	0.39	0.39
Benzo(g,h,i)perylene			0.77	U			0.76	U			0.77	U		
Benzo[b]Fluoranthene	0.10	0.10	4.00		0.40	0.40	3.90		0.39	0.39	4.00		0.40	0.40
Benzo[k]fluoranthene	0.01	0.10	0.93		0.0093	0.09	0.76	U	0.0038	0.04	0.77	U	0.0039	0.04
Chrysene	0.001	0.01	2.50		0.0025	0.03	3.00		0.0030	0.03	2.60		0.0026	0.03
Dibenzo[a,h]anthracene	1.00	0.10	0.77	U	0.39	0.04	0.76	U	0.38	0.04	0.77	U	0.39	0.04
Fluoranthene			11.00				16.00				13.00			
Indeno(1,2,3-cd)pyrene	0.10	0.10	3.70		0.37	0.37	3.30		0.33	0.33	3.50		0.35	0.35
Naphthalene			2.40	U			2.80	U			2.60	U		
Naphthalene, 1-methyl-			0.80				1.20				0.83			
Naphthalene, 2-methyl-			1.90	U			2.40	U			2.00	U		
Phenanthrene			8.60				12.00				9.40			
Pyrene			9.70				12.00				11.00			
Lipids%			0.44				0.63				0.33			
Total cPAH (ND = 0.5 *RL)			14.6				14.14				13.655			
Total cPAH (ND = 0)			13.83				13.00				12.50			
Total EPA B[a]P EQ (ND = 0.5 * RL)					1.82				1.77				1.77	
Total EPA B[a]P EQ (ND = 0)					1.05				1.00				0.99	
Total MTCA TEQ (ND = 0.5 *RL)						1.58				1.49				1.48
Total MTCA TEQ (ND = 0)						1.16				1.03				1.02

Analytical Results Notes:

- U = Analyte not detected at the reporting limit
- J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:

For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3.6 - 2016 Clam Tissue Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			Point No Point #1			
Compound	EPA B[a]P Relative Potency Factor (RPF)	MTCA B[a]P Toxicity Equivalency Factor (TEF)	Result ug/kg-w	Q	EPA B[a]P - equivalent (ug/kg)	MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			0.76	U		
Acenaphthene			0.76	U		
Acenaphthylene			0.76	U		
Anthracene			0.76	U		
Benzo(a)anthracene	0.10	0.10	0.76	U	0.04	0.076
Benzo(a)pyrene	1.00	1.00	0.76	U	0.38	0.76
Benzo(g,h,i)perylene			0.76	U		
Benzo[b]Fluoranthene	0.10	0.10	0.76	U	0.04	0.076
Benzo[k]fluoranthene	0.01	0.10	0.76	U	0.0038	0.076
Chrysene	0.001	0.01	0.76	U	0.0004	0.0076
Dibenzo[a,h]anthracene	1.00	0.10	0.76	U	0.38	0.076
Fluoranthene			0.76	U		
Indeno(1,2,3-cd)pyrene	0.10	0.10	2.50		0.25	0.25
Naphthalene			2.10	U		
Naphthalene, 1-methyl-			0.76	U		
Naphthalene, 2-methyl-			1.40	U		
Phenanthrene			0.76	U		
Pyrene			0.76	U		
Lipids%			0.38			
Total cPAH (ND = 0.5 *RL)			4.78			
Total cPAH (ND = 0)			2.50			
Total EPA B[a]P EQ (ND = 0.5 * RL)					1.09	
Total EPA B[a]P EQ (ND = 0)					0.25	
Total MTCA TEQ (ND = 0.5 *RL)						1.32
Total MTCA TEQ (ND = 0)						0.25

Analytical Results Notes:

- U = Analyte not detected at the reporting limit
- J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:

For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3-7. 2011, 2014, and 2016 Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			EAST BEACH # 1											
Compound	EPA B[a]P Relative Potency	MTCA B[a]P Toxicity Equivalency	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			0.93	U	0.82	U	2.30							
Acenaphthene			0.93	U	0.82	U	2.10							
Acenaphthylene			0.93	U	0.82	U	0.77	U						
Anthracene			4.50		0.82	U	3.00							
Benzo(a)anthracene	0.10	0.10	2.10		0.82	U	3.40		0.21	0.21	0.04	0.082	0.34	0.34
Benzo(a)pyrene	1.00	1.00	1.20		0.82	U	0.98		1.20	1.20	0.41	0.82	0.98	0.98
Benzo(g,h,i)perylene			5.70		0.82	U	1.30							
Benzo[b]Fluoranthene	0.10	0.10	0.93	U	1.10		3.400		0.05	0.0465	0.11	0.11	0.34	0.34
Benzo[k]fluoranthene	0.01	0.10	0.93	U	0.82	U	1.00		0.005	0.0465	0.004	0.082	0.010	0.10
Chrysene	0.001	0.01	1.90	U	1.40		3.50		0.001	0.0095	0.001	0.014	0.004	0.04
Dibenzo[a,h]anthracene	1.00	0.10	0.93	U	0.82	U	0.77	U	0.47	0.0465	0.41	0.082	0.39	0.04
Fluoranthene			3.90		3.70		17.00							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.90	U	0.82	U	5.20		0.10	0.095	0.04	0.082	0.52	0.52
Naphthalene			1.10	U	0.82	U	2.60	U						
Naphthalene, 1-methyl-					3.90		1.10							
Naphthalene, 2-methyl-			14.00	U	9.00		2.30	U						
Phenanthrene			3.30		2.00		12.00							
Pyrene			4.80		5.00		14.00							
Lipids%			0.54		0.74		0.49							
Total cPAH (ND = 0.5 *RL)			9.89		6.60		17.87							
Total cPAH (ND = 0)			3.30		2.50		17.48							
Total EPA B[a]P EQ (ND = 0.5 * RL)									2.02		1.02		2.58	
Total EPA B[a]P EQ (ND = 0)									1.41		0.11		2.19	
Total MTCA TEQ (ND = 0.5 *RL)										1.65		1.27		2.35
Total MTCA TEQ (ND = 0)										1.41		0.124		2.32

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3-7. 2011, 2014, and 2016 Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			EAST BEACH # 2											
Compound	EPA B[a]P Relative Potency	MTCA B[a]P Toxicity Equivalency	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.6		1.2		2.70							
Acenaphthene			1.6		1.2		2.70							
Acenaphthylene			0.93	U	0.8	U	0.74	U						
Anthracene			4.3		0.8	U	3.10							
Benzo(a)anthracene	0.10	0.10	3		1		4.60	J	0.30	0.30	0.10	0.10	0.46	0.46
Benzo(a)pyrene	1.00	1.00	1.6		0.8	U	0.85		1.60	1.60	0.80	0.40	0.85	0.85
Benzo(g,h,i)perylene			5.1		0.8	U	0.74	U						
Benzo[b]Fluoranthene	0.10	0.10	1.7		1.7		3.30		0.17	0.17	0.17	0.17	0.33	0.33
Benzo[k]fluoranthene	0.01	0.10	0.93	U	0.82		0.79		0.005	0.05	0.01	0.08	0.01	0.08
Chrysene	0.001	0.01	1.9	U	3.2		4.20		0.001	0.01	0.003	0.03	0.004	0.04
Dibenzo[a,h]anthracene	1.00	0.10	0.93	U	0.8	U	0.74	U	0.47	0.05	0.80	0.04	0.37	0.04
Fluoranthene			7.6		6.7		22.00							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.9	U	0.8	U	1.20	J	0.10	0.10	0.08	0.04	0.12	0.12
Naphthalene			1.4	U	2.6	U	2.10	U						
Naphthalene, 1-methyl-					3.3		0.97							
Naphthalene, 2-methyl-			13	U	7.1		1.90	U						
Phenanthrene			6.7		4.1		18.00							
Pyrene			11		15		21.00							
Lipids%			0.49		0.72		0.53							
Total cPAH (ND = 0.5 *RL)			11.96		9.12		15.31							
Total cPAH (ND = 0)			6.30		6.72		14.94							
Total EPA B[a]P EQ (ND = 0.5 * RL)									2.64		1.96		2.14	
Total EPA B[a]P EQ (ND = 0)									2.07		0.28		1.77	
Total MTCA TEQ (ND = 0.5 *RL)										2.27		0.86		1.918
Total MTCA TEQ (ND = 0)										2.07		0.38		1.881

Analytical Results Notes:

- U = Analyte not detected at the reporting limit
- J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:

For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3-7. 2011, 2014, and 2016 Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			EAST BEACH #3											
Compound	EPA B[a]P Relative Potency	MTCA B[a]P Toxicity Equivalency	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.10		1.20		3.40							
Acenaphthene			1.00		0.88		3.00							
Acenaphthylene			0.95	U	0.84	U	0.75	U						
Anthracene			5.20		0.84	U	4.20							
Benzo(a)anthracene	0.10	0.10	2.90		0.84	U	5.60	J	0.29	0.29	0.04	0.04	0.56	0.56
Benzo(a)pyrene	1.00	1.00	1.90		0.84	U	0.98		1.90	1.90	0.42	0.42	0.98	0.98
Benzo(g,h,i)perylene			6.00		0.84	U	0.75	U						
Benzo[b]Fluoranthene	0.10	0.10	1.90		1.20		4.80		0.19	0.19	0.12	0.12	0.48	0.48
Benzo[k]fluoranthene	0.01	0.10	0.95	U	0.84	U	0.99		0.005	0.05	0.004	0.04	0.01	0.10
Chrysene	0.001	0.01	1.90	U	2.20		5.00		0.001	0.01	0.002	0.02	0.01	0.05
Dibenzo[a,h]anthracene	1.00	0.10	0.95	U	0.84	U	0.75	U	0.48	0.05	0.42	0.04	0.38	0.04
Fluoranthene			5.20		6.60		22.00							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.90	U	0.84	U	0.75	U	0.10	0.10	0.04	0.04	0.04	0.04
Naphthalene			1.50	U	2.70	U	2.60	U						
Naphthalene, 1-methyl-			4.10		4.10		1.50							
Naphthalene, 2-methyl-			1.60	U	9.00		2.30	U						
Phenanthrene			4.70		4.00		16.00							
Pyrene			26.00		8.40		27.00							
Lipids%			0.40		1.10		0.56							
Total cPAH (ND = 0.5 *RL)			12.40		7.60		18.12							
Total cPAH (ND = 0)			6.70		3.40		17.37							
Total EPA B[a]P EQ (ND = 0.5 * RL)									2.96		1.05		2.45	
Total EPA B[a]P EQ (ND = 0)									2.38		0.12		2.03	
Total MTCA TEQ (ND = 0.5 *RL)										2.58		0.73		2.244
Total MTCA TEQ (ND = 0)										2.38		0.14		2.169

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3-7. 2011, 2014, and 2016 Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			INTERDIAL CAP #1											
Compound	EPA B[a]P Relative Potency	MTCA B[a]P Toxicity Equivalency	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.20		1.60		2.70							
Acenaphthene			0.99		1.40		2.30							
Acenaphthylene			1.20		0.83	U	0.76	U						
Anthracene			9.60		0.83	U	3.50							
Benzo(a)anthracene	0.10	0.10	2.40		0.83	U	3.50		0.24	0.24	0.04	0.04	0.35	0.35
Benzo(a)pyrene	1.00	1.00	1.30		0.83	U	0.76	U	1.30	1.30	0.42	0.42	0.38	0.38
Benzo(g,h,i)perylene			5.10		0.83	U	0.76	U						
Benzo[b]Fluoranthene	0.10	0.10	2.20		1.40		4.60		0.22	0.22	0.14	0.14	0.46	0.46
Benzo[k]fluoranthene	0.01	0.10	0.92	U	0.83	U	0.81		0.005	0.05	0.004	0.04	0.01	0.08
Chrysene	0.001	0.01	1.80	U	3.50		3.70		0.001	0.01	0.004	0.04	0.004	0.04
Dibenzo[a,h]anthracene	1.00	0.10	0.92	U	0.83	U	0.76	U	0.46	0.05	0.42	0.04	0.38	0.04
Fluoranthene			7.30		9.60		19.00							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.80	U	0.83	U	3.30		0.09	0.09	0.04	0.08	0.33	0.33
Naphthalene			1.10	U	2.70	U	2.40	U						
Naphthalene, 1-methyl-					1.70	U	0.86							
Naphthalene, 2-methyl-			1.50	U	3.50	U	2.00	U						
Phenanthrene			4.80		6.60		14.00							
Pyrene			11.00		13.00		15.00							
Lipids%			0.47		0.78		0.56							
Total cPAH (ND = 0.5 *RL)			11.34		9.05		16.67							
Total cPAH (ND = 0)			5.90		4.90		15.91							
Total EPA B[a]P EQ (ND = 0.5 * RL)									2.59		1.06		1.91	
Total EPA B[a]P EQ (ND = 0)									1.76		0.14		1.15	
Total MTCA TEQ (ND = 0.5 *RL)										1.95		0.80		1.68
Total MTCA TEQ (ND = 0)										1.76		0.18		1.26

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3-7. 2011, 2014, and 2016 Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			INTERTIDAL CAP # 2											
Compound	EPA B[a]P Relative Potency	MTCA B[a]P Toxicity Equivalency	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.20		0.91		2.40							
Acenaphthene			0.93	U	0.85	U	2.00							
Acenaphthylene			1.10		0.85	U	0.75	U						
Anthracene			10.00		0.85	U	2.90							
Benzo(a)anthracene	0.10	0.10	2.20		0.85	U	3.30		0.22	0.22	0.04	0.04	0.33	0.33
Benzo(a)pyrene	1.00	1.00	1.10		0.85	U	0.75	U	1.10	1.10	0.43	0.43	0.38	0.38
Benzo(g,h,i)perylene			6.80		0.85	U	0.75	U						
Benzo[b]fluoranthene	0.10	0.10	1.80		1.10		3.80		0.18	0.18	0.11	0.11	0.38	0.38
Benzo[k]fluoranthene	0.01	0.10	0.93	U	0.85	U	0.80		0.005	0.05	0.004	0.04	0.008	0.08
Chrysene	0.001	0.01	1.90	U	2.40		3.20		0.001	0.01	0.002	0.02	0.003	0.03
Dibenzo[a,h]anthracene	1.00	0.10	0.93	U	0.85	U	0.75	U	0.47	0.05	0.43	0.04	0.38	0.04
Fluoranthene			7.30		6.50		15.00							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.90	U	0.85	U	4.00		0.10	0.10	0.04	0.04	0.40	0.40
Naphthalene			0.93	U	2.70	U	2.50	U						
Naphthalene, 1-methyl-					1.10	U	0.87							
Naphthalene, 2-methyl-			13.00	U	2.00	U	1.80	U						
Phenanthrene			5.20		4.10		12.00							
Pyrene			7.10		8.50		12.00							
Lipids%			0.55		0.59		0.49							
Total cPAH (ND = 0.5 *RL)			10.76		7.75		15.85							
Total cPAH (ND = 0)			5.10		3.50		15.10							
Total EPA B[a]P EQ (ND = 0.5 * RL)									2.07		1.05		1.87	
Total EPA B[a]P EQ (ND = 0)									1.50		0.11		1.12	
Total MTCA TEQ (ND = 0.5 *RL)										1.70		0.73		1.63
Total MTCA TEQ (ND = 0)										1.50		0.13		1.22

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3-7. 2011, 2014, and 2016 Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			INTERTIDAL CAP # 3											
Compound	EPA B[a]P Relative Potency	MTCA B[a]P Toxicity Equivalency	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.40		0.81	U	1.20							
Acenaphthene			0.99		0.81	U	0.98							
Acenaphthylene			1.60		0.81	U	0.78	U						
Anthracene			17.00		0.81	U	1.80							
Benzo(a)anthracene	0.10	0.10	3.40		0.81	U	1.70		0.34	0.34	0.04	0.04	0.17	0.17
Benzo(a)pyrene	1.00	1.00	1.50		0.81	U	0.78	U	1.50	1.50	0.41	0.41	0.39	0.39
Benzo(g,h,i)perylene			6.20		0.81	U	0.78	U						
Benzo[b]fluoranthene	0.10	0.10	2.60		1.10		2.00		0.26	0.26	0.11	0.11	0.20	0.20
Benzo[k]fluoranthene	0.01	0.10	0.95	U	0.81	U	0.78	U	0.005	0.05	0.004	0.04	0.004	0.04
Chrysene	0.001	0.01	1.90	U	1.60		1.70		0.001	0.01	0.002	0.02	0.002	0.02
Dibenzo[a,h]anthracene	1.00	0.10	0.95	U	0.81	U	0.78	U	0.48	0.05	0.41	0.04	0.39	0.04
Fluoranthene			7.30		2.70		8.70							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.90	U	0.81	U	3.40		0.10	0.10	0.04	0.04	0.34	0.34
Naphthalene			1.30	U	2.60	U	1.70	U						
Naphthalene, 1-methyl-			1.90		1.20	U	0.78	U						
Naphthalene, 2-methyl-			1.70	U	2.80	U	1.20	U						
Phenanthrene			4.50		1.90		5.50							
Pyrene			9.70		4.40		6.90							
Lipids%			0.71		0.47		0.49							
Total cPAH (ND = 0.5 *RL)			13.20		6.75		9.97							
Total cPAH (ND = 0)			7.50		2.70		8.80							
Total EPA B[a]P EQ (ND = 0.5 * RL)									2.68		1.01		1.50	
Total EPA B[a]P EQ (ND = 0)									2.10		0.11		0.71	
Total MTCA TEQ (ND = 0.5 *RL)										2.30		0.69		1.20
Total MTCA TEQ (ND = 0)										2.10		0.13		0.73

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3-7. 2011, 2014, and 2016 Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			NORTH SHOAL # 1											
Compound	EPA B[a]P Relative Potency	MTCA B[a]P Toxicity Equivalency	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.70		1.30		3.70							
Acenaphthene			1.20		1.20		3.10							
Acenaphthylene			1.40		0.85	U	0.75	U						
Anthracene			10.00		0.88		3.40							
Benzo(a)anthracene	0.10	0.10	2.80		0.96		4.30		0.28	0.28	0.10	0.10	0.43	0.43
Benzo(a)pyrene	1.00	1.00	3.40		0.85	U	0.99		3.40	3.40	0.43	0.43	0.99	0.99
Benzo(g,h,i)perylene			5.80		0.85	U	0.75	U						
Benzo[b]Fluoranthene	0.10	0.10	4.20		2.30		4.90		0.42	0.42	0.23	0.23	0.49	0.49
Benzo[k]fluoranthene	0.01	0.10	1.20		0.97		1.00		0.01	0.12	0.010	0.10	0.010	0.10
Chrysene	0.001	0.01	1.90	U	3.20		5.00		0.001	0.010	0.00	0.03	0.005	0.05
Dibenzo[a,h]anthracene	1.00	0.10	0.95	U	0.85	U	0.75	U	0.48	0.05	0.43	0.04	0.38	0.04
Fluoranthene			11.00		8.20		26.00							
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.90	U	0.85	U	0.75	U	0.10	0.10	0.04	0.04	0.04	0.04
Naphthalene			1.80	U	2.80	U	2.80	U						
Naphthalene, 1-methyl-					2.00	U	1.30							
Naphthalene, 2-methyl-			1.00	U	4.30		2.30	U						
Phenanthrene			6.40		5.90		20.00							
Pyrene			24.00		11.00		27.00							
Lipids%			0.56		0.68		0.57							
Total cPAH (ND = 0.5 *RL)			16.35		9.98		16.94							
Total cPAH (ND = 0)			11.60		7.43		16.19							
Total EPA B[a]P EQ (ND = 0.5 * RL)									4.68		1.23		2.34	
Total EPA B[a]P EQ (ND = 0)									4.11		0.34		1.93	
Total MTCA TEQ (ND = 0.5 *RL)										4.37		0.97		2.14
Total MTCA TEQ (ND = 0)										4.22		0.46		2.06

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3-7. 2011, 2014, and 2016 Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			NORTH SHOAL # 2								NORTH SHOAL # 3							
Compound	EPA B[a]P Relative Potency	MTCA B[a]P Toxicity Equivalency	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2011 Result ug/kg-w	2011 Qualifier	2014 Result ug/kg-w	2014 Qualifier	2011 EPA B[a]P - equivalent (ug/kg)	2011 MTCA B[a]P - equivalent (ug/kg)	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			1.50		1.20						9.00		4.10					
Acenaphthene			1.40		0.92						1.50		5.90					
Acenaphthylene			1.20	U	0.82	U					1.30		0.85	U				
Anthracene			9.90	U	0.82	U					11.00		6.80					
Benzo(a)anthracene	0.10	0.10	3.50		0.97		0.35	0.35	0.10	0.10	2.60		8.70		0.26	0.26	0.87	0.87
Benzo(a)pyrene	1.00	1.00	3.00	U	0.82	U	1.50	1.50	0.41	0.41	2.30		3.70		2.30	2.30	3.70	3.70
Benzo(g,h,i)perylene			5.20	U	0.82	U					4.30		0.85	U				
Benzo[b]Fluoranthene	0.10	0.10	3.30		1.50		0.33	0.33	0.15	0.15	2.90		9.30		0.29	0.29	0.93	0.93
Benzo[k]fluoranthene	0.01	0.10	1.10		0.82		0.011	0.110	0.01	0.08	1.40		3.10		0.014	0.140	0.03	0.31
Chrysene	0.001	0.01	1.80		3.50		0.002	0.018	0.004	0.04	1.90	U	16.00		0.001	0.010	0.02	0.16
Dibenzo[a,h]anthracene	1.00	0.10	0.91	U	0.82	U	0.46	0.05	0.41	0.04	0.94	U	0.85	U	0.47	0.05	0.43	0.04
Fluoranthene			15.00		8.60						9.00		76.00					
Indeno(1,2,3-cd)pyrene	0.10	0.10	1.80	U	0.82	U	0.09	0.09	0.04	0.04	1.90	U	1.10		0.10	0.10	0.11	0.11
Naphthalene			2.10	U	2.60	U					2.00	U	3.20	U				
Naphthalene, 1-methyl-				U	2.40	U							4.30					
Naphthalene, 2-methyl-			1.00		5.00						1.60	U	8.10					
Phenanthrene			6.70		6.50						7.00		16.00					
Pyrene			26.00		10.00						14.00		130.00					
Lipids%			0.53		0.67						0.48		0.80					
Total cPAH (ND = 0.5 *RL)			15.41		9.25						13.94		42.75					
Total cPAH (ND = 0)			9.70		6.79						9.20		41.90					
Total EPA B[a]P EQ (ND = 0.5 * RL)							2.74		1.12						3.43		6.08	
Total EPA B[a]P EQ (ND = 0)							0.69		0.26						2.86		5.66	
Total MTCA TEQ (ND = 0.5 *RL)								2.44		0.86						3.14		6.12
Total MTCA TEQ (ND = 0)								0.81		0.36						2.99		6.08

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3-7. 2011, 2014, and 2016 Polycyclic Aromatic Hydrocarbon Tissue Results

Sample Location:			West Beach #1								West Beach #2							
Compound	EPA B[a]P Relative Potency	MTCA B[a]P Toxicity Equivalency	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			0.83	U	2.20						0.84	U	3.10					
Acenaphthene			0.83	U	1.90						0.84	U	3.30					
Acenaphthylene			0.83	U	0.77	U					0.84	U	0.76	U				
Anthracene			0.83	U	2.30						0.84	U	3.00					
Benzo(a)anthracene	0.10	0.10	0.83	U	2.70		0.04	0.04	0.27	0.27	0.84	U	2.80		0.04	0.04	0.28	0.28
Benzo(a)pyrene	1.00	1.00	0.83	U	0.77	U	0.42	0.42	0.39	0.385	0.84	U	0.76	U	0.42	0.42	0.38	0.38
Benzo(g,h,i)perylene			0.83	U	0.77	U					0.84	U	0.76	U				
Benzo[b]Fluoranthene	0.10	0.10	1.10		4.00		0.11	0.11	0.40	0.4	0.99		3.90		0.10	0.10	0.39	0.39
Benzo[k]fluoranthene	0.01	0.10	0.83	U	0.93		0.004	0.042	0.009	0.093	0.84	U	0.76	U	0.004	0.042	0.004	0.04
Chrysene	0.001	0.01	1.70		2.50		0.002	0.017	0.003	0.025	1.80		3.00		0.002	0.018	0.003	0.03
Dibenzo[a,h]anthracene	1.00	0.10	0.83	U	0.77	U	0.42	0.04	0.39	0.0385	0.84	U	0.76	U	0.42	0.04	0.38	0.04
Fluoranthene			4.90		11.00						3.30		16.00					
Indeno(1,2,3-cd)pyrene	0.10	0.10	0.83	U	3.70		0.04	0.04	0.37	0.37	0.84	U	3.30		0.04	0.04	0.33	0.33
Naphthalene			2.70	U	2.40	U					2.70	U	2.80	U				
Naphthalene, 1-methyl-			1.60	U	0.80						1.00	U	1.20					
Naphthalene, 2-methyl-			3.40	U	1.90	U					2.30	U	2.40	U				
Phenanthrene			3.00		8.60						2.20		12.00					
Pyrene			4.90		9.70						5.10		12.00					
Lipids%			0.36		0.44						0.42		0.63					
Total cPAH (ND = 0.5 *RL)			6.95		14.60						6.99		14.14					
Total cPAH (ND = 0)			2.80		13.83						2.79		13.00					
Total EPA B[a]P EQ (ND = 0.5 * RL)							1.03		1.82						1.03		1.77	
Total EPA B[a]P EQ (ND = 0)							0.11		1.05						0.10		1.00	
Total MTCA TEQ (ND = 0.5 *RL)								0.71		1.5815						0.71		1.49
Total MTCA TEQ (ND = 0)								0.13		1.158						0.12		1.03

Analytical Results Notes:
U = Analyte not detected at the reporting limit
J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:
For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)

Table 3-7. 2011, 2014, and 2016 Polycyclic Aromatic Hydrocarbon Tissue Results

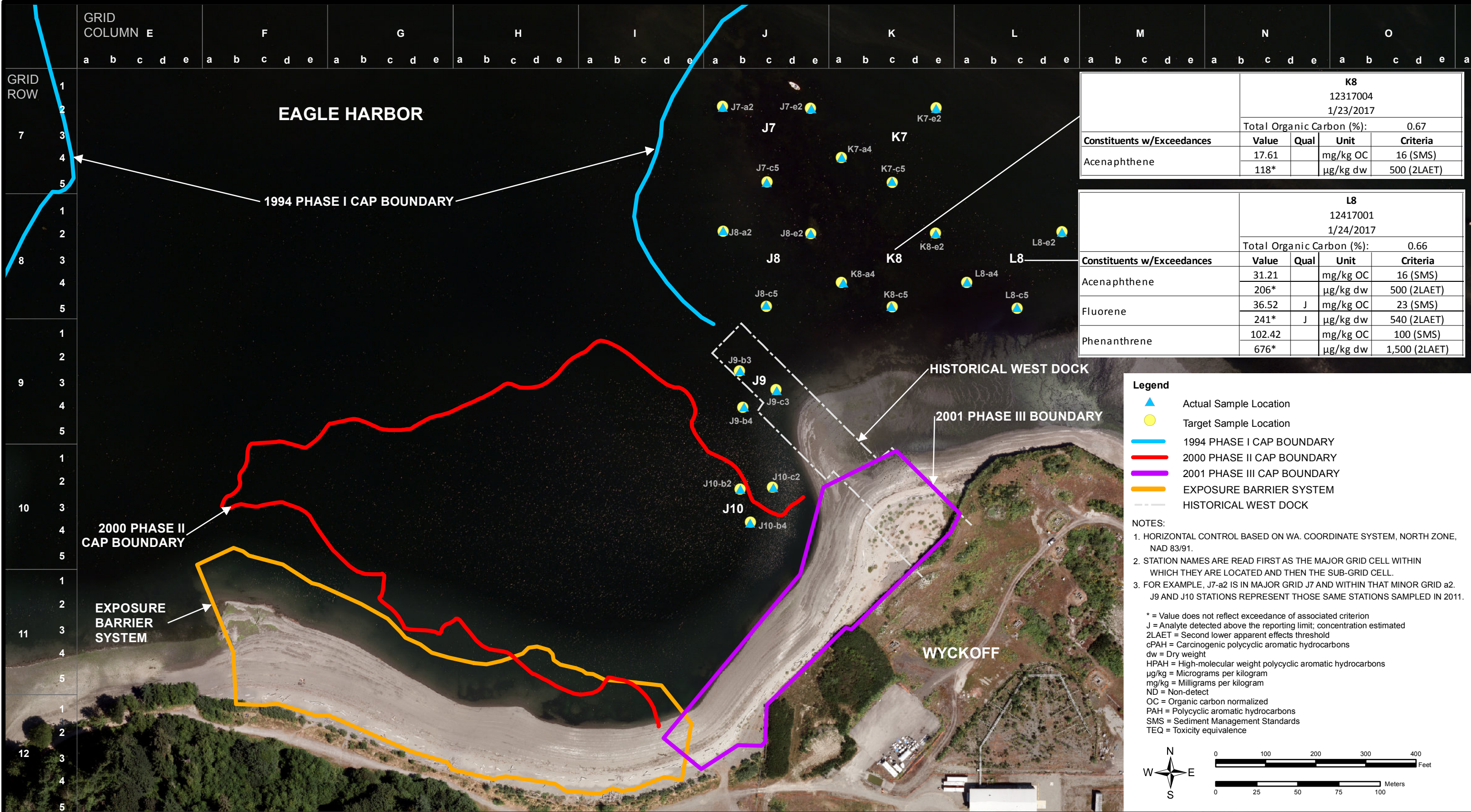
Sample Location:			West Beach #3							
Compound	EPA B[a]P Relative Potency	MTCA B[a]P Toxicity Equivalency	2014 Result ug/kg-w	2014 Qualifier	2016 Result ug/kg-w	2016 Qualifier	2014 EPA B[a]P - equivalent (ug/kg)	2014 MTCA B[a]P - equivalent (ug/kg)	2016 EPA B[a]P - equivalent (ug/kg)	2016 MTCA B[a]P - equivalent (ug/kg)
9H-Fluorene			0.80	U	2.30					
Acenaphthene			0.80	U	1.90					
Acenaphthylene			0.80	U	0.77	U				
Anthracene			0.80	U	2.10					
Benzo(a)anthracene	0.10	0.10	0.80	U	2.40		0.04	0.04	0.24	0.24
Benzo(a)pyrene	1.00	1.00	0.80	U	0.77	U	0.40	0.40	0.39	0.385
Benzo(g,h,i)perylene			0.80	U	0.77	U				
Benzo[b]Fluoranthene	0.10	0.10	0.96		4.00		0.10	0.10	0.40	0.4
Benzo[k]fluoranthene	0.01	0.10	0.80	U	0.77	U	0.004	0.040	0.004	0.0385
Chrysene	0.001	0.01	1.80		2.60		0.002	0.018	0.003	0.026
Dibenzo[a,h]anthracene	1.00	0.10	0.80	U	0.77	U	0.40	0.04	0.39	0.0385
Fluoranthene			3.90		13.00					
Indeno(1,2,3-cd)pyrene	0.10	0.10	0.80	U	3.50		0.04	0.04	0.35	0.35
Naphthalene			2.60	U	2.60	U				
Naphthalene, 1-methyl-			1.70	U	0.83					
Naphthalene, 2-methyl-			3.50	U	2.00	U				
Phenanthrene			2.60		9.40					
Pyrene			4.50		11.00					
Lipids%			0.44		0.33					
Total cPAH (ND = 0.5 *RL)			6.76		13.66					
Total cPAH (ND = 0)			2.76		12.50					
Total EPA B[a]P EQ (ND = 0.5 * RL)							0.98		1.77	
Total EPA B[a]P EQ (ND = 0)							0.10		0.99	
Total MTCA TEQ (ND = 0.5 *RL)								0.67		1.478
Total MTCA TEQ (ND = 0)								0.11		1.016

Analytical Results Notes:

- U = Analyte not detected at the reporting limit
- J = Analyte detected above the reporting limit; concentration estimated

TEQ Calculation Specific Notes:

For non-detect data 1/2 of the reporting limit was used in the summary of cPAH.
B[a]P EQ = benzo(a)pyrene equivalence calculated as the [result value] * [chemical specific RPF]
cPAH = carcinogenic Polycyclic Aromatic Hydrocarbon
EPA = US Environmental Protection Agency
FD = field duplicate
MTCA = Model Toxics Control Act
ND = non-detect
µg/kg-w = micrograms per kilogram wet weight
TEF = Toxicity Equivalency Factor (MTCA WAC 173-340-708(8)(e), 2013)
TEQ = Toxicity Equivalence concentration calculated as the [result value] * [chemical specific TEF]
RL = reporting limit
RPF = Relative Potency Factor (EPA 1993)



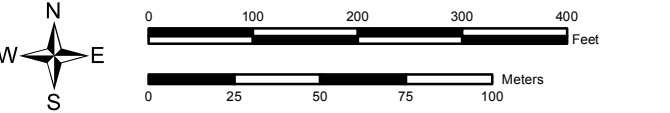
Constituents w/Exceedances	K8			
	12317004			
	1/23/2017			
	Total Organic Carbon (%): 0.67			
Acenaphthene	Value	Qual	Unit	Criteria
	17.61		mg/kg OC	16 (SMS)
	118*		µg/kg dw	500 (2LAET)

Constituents w/Exceedances	L8			
	12417001			
	1/24/2017			
	Total Organic Carbon (%): 0.66			
Acenaphthene	Value	Qual	Unit	Criteria
	31.21		mg/kg OC	16 (SMS)
	206*		µg/kg dw	500 (2LAET)
Fluorene	36.52	J	mg/kg OC	23 (SMS)
	241*	J	µg/kg dw	540 (2LAET)
Phenanthrene	102.42		mg/kg OC	100 (SMS)
	676*		µg/kg dw	1,500 (2LAET)

- Legend**
- ▲ Actual Sample Location
 - Target Sample Location
 - 1994 PHASE I CAP BOUNDARY
 - 2000 PHASE II CAP BOUNDARY
 - 2001 PHASE III CAP BOUNDARY
 - EXPOSURE BARRIER SYSTEM
 - - - HISTORICAL WEST DOCK

- NOTES:**
- HORIZONTAL CONTROL BASED ON WA. COORDINATE SYSTEM, NORTH ZONE, NAD 83/91.
 - STATION NAMES ARE READ FIRST AS THE MAJOR GRID CELL WITHIN WHICH THEY ARE LOCATED AND THEN THE SUB-GRID CELL.
 - FOR EXAMPLE, J7-a2 IS IN MAJOR GRID J7 AND WITHIN THAT MINOR GRID a2. J9 AND J10 STATIONS REPRESENT THOSE SAME STATIONS SAMPLED IN 2011.

* = Value does not reflect exceedance of associated criterion
J = Analyte detected above the reporting limit; concentration estimated
2LAET = Second lower apparent effects threshold
cPAH = Carcinogenic polycyclic aromatic hydrocarbons
dw = Dry weight
HPAH = High-molecular weight polycyclic aromatic hydrocarbons
µg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
ND = Non-detect
OC = Organic carbon normalized
PAH = Polycyclic aromatic hydrocarbons
SMS = Sediment Management Standards
TEQ = Toxicity equivalence



Project Name

Figure Name



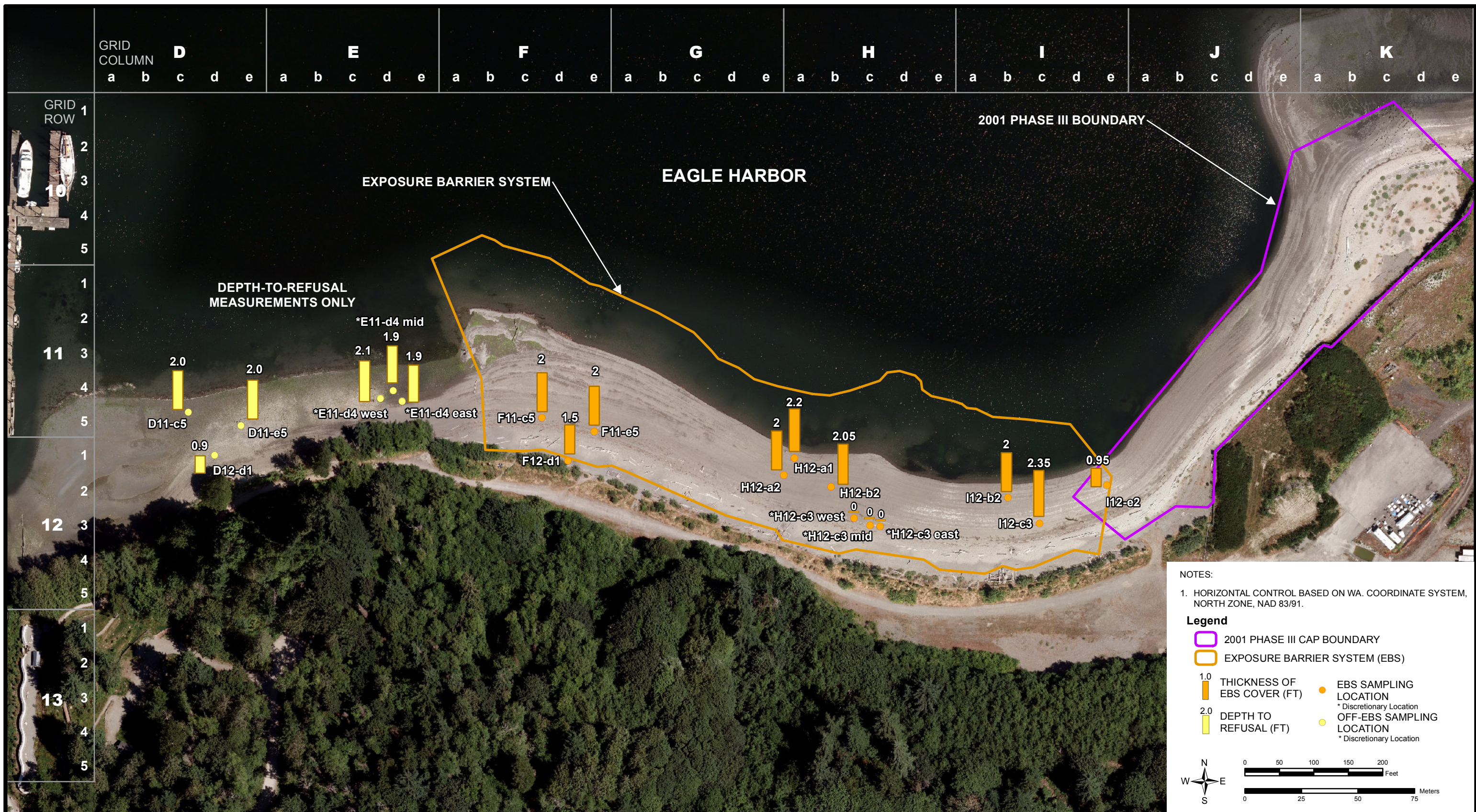
2016 OMMP Implementation
East Harbor Operable Unit
Wyckoff/Eagle Harbor Superfund Site

Subtidal Surface Sediment Chemistry Results Compared to
East Harbor Operable Unit Remedial Action Levels

Figure
3-1



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Project Name

Figure Name



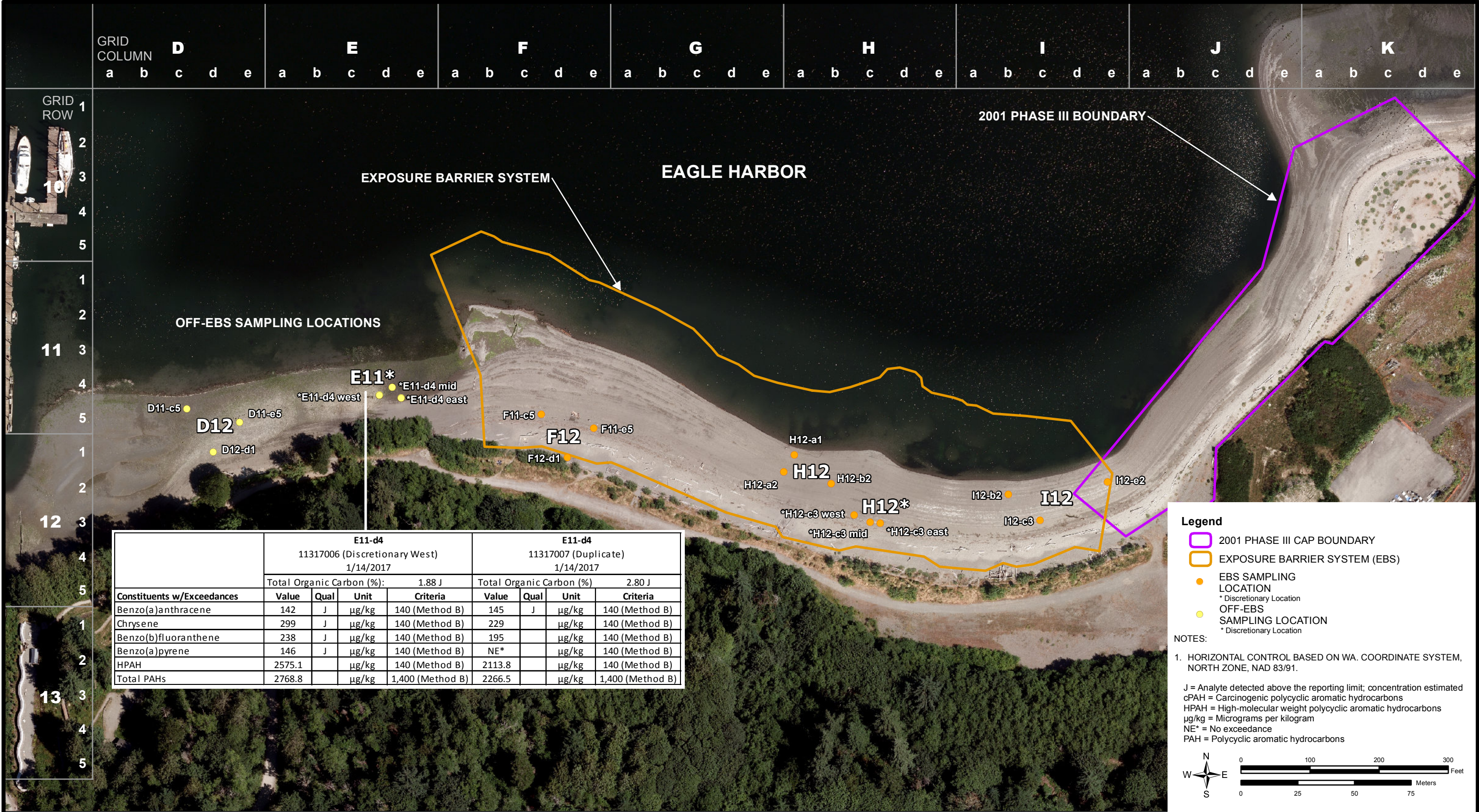
2016 OMMP Implementation
East Harbor Operable Unit
Wyckoff/Eagle Harbor Superfund Site

Exposure Barrier System Cover Thickness Measurements

Figure
3-2



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Project Name

Figure Name



2016 OMMP Implementation
East Harbor Operable Unit
Wyckoff/Eagle Harbor Superfund Site

Exposure Barrier System and Off-Exposure Barrier System
Sediment Chemistry Results Compared to
East Harbor Operable Unit Remedial Action Levels

Figure
3-3



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4 Discussion of Monitoring Results

4.1 Evaluation of Monitoring Objectives

The overall goal of the Year 22 monitoring program established in the OMMP is to evaluate the performance of the implemented remedies at West Beach as defined in the ROD and the subsequent ESD. The specific monitoring objectives defined for the ESB in Table 1-2 were to provide the data necessary to support an O&F determination for the ESB. The O&F determination can be made if (1) the ESB is physically stable, (2) measured contaminant concentrations are protective of human health and the environment, and (3) if the remedy provides functioning habitat and whether shellfish are safe for human consumption.

In the Year 22 monitoring, additional information was collected within subtidal grids J9 and J10 (in the vicinity of the former historical West Dock) and in North Shoal subtidal grid cells J7, J8, K7, K8, and L8 to further inform potential future remedial and administrative actions by EPA.

Physical and chemical monitoring on the subtidal caps (Phases I, II, and III) are deferred until after completion of additional proposed remedies at the EHO. Monitoring of the progress of MNR at the North Shoal and East Beach is also deferred for future events after completion of planned remedial actions.

This section summarizes the results of the Year 22 monitoring program presented in Section 3 relative to the area objectives, evaluation processes, and criteria developed in the 2016 OMMP Addendum (see Table 1-2). Results and conclusions are also compared to those similar objectives and processes articulated in the 2011 Year 17 monitoring report (HDR and SEE 2012).

4.2 Analytical Reporting Limits

The sediment chemical data reported as part of the Year 22 monitoring program were at or below the required RLs for PAHs, with respect to applicable screening criteria established for the EHO. In addition, the RLs for the additional SMS chemicals of concern (i.e., mercury and PCP) met the required RL, based on the established criteria.

The sediment data validation reports (Appendix H) demonstrate that overall, these data are of sufficient quality, with qualification in some instances, to support remedy review and decision-making. To be consistent with the laboratory reporting format, non-detect results were reported as non-detect at the RLs for this project.

The clam tissue samples collected by the USACE were analyzed by EPA Region 10's Manchester Environmental Laboratory in accordance with the 2016 Clam Tissue QAPP (Appendix D.2). The Manchester Environmental Laboratory's LOQ for the seven cPAHs was reported to range between 1 and 2 µg/kg; (sufficient to resolve between 6.06 E-6 and 1.21 E-5 cancer risk for the child Tribal subsistence consumer). The only issue concerning data quality was that the single clam collected at the North Shoal did not provide the laboratory with the minimum amount of tissue sample needed to provide the

targeted RLs. Overall, the data were found to be of sufficient quality to support the O&F determination.

4.3 Subtidal Sediment Cap Performance in the Vicinity of J9 and J10

The O&F determination for J9 and J10 requires an evaluation of the physical stability and chemical isolation relative to the SQS/MCUL criteria in those grids. For the Year 22 monitoring, the focus of the area defined by grids J9 and J10 was the evaluation of surface sediment chemical concentrations.

Three discrete surface samples were collected within each of these two grids. The three collected samples were composited into a single sample for each grid, analyzed, and compared to the SQS/MCUL criteria, as applicable. This method differs from that used during the 2011 sampling event where the three collected discrete samples were analyzed separately. The physical evaluation included only observations made during surface sediment grab sample collection, and the grain size of the collected composite sample.

4.3.1 Is the Cap in the Vicinity of J9/J10 Physically Stable, Remaining in Place at a Desired Thickness?

The Year 17 monitoring (2011) concluded that sediments at station J9 may not be physically stable, and did not have the requisite cover thickness. Three of the four 2011 coring locations exhibited a complete lack of cover material (J9b, J9c, and J9d), while J9a had only 1.2 ft of Phase II/III capping material. Whether this lack of cap material was due to erosion or because J9 did not receive either Phase I or Phase II cover material is unknown. Grid J9 is outside both the Phase I and Phase II cap boundaries (Figure 3-1). The complete absence of Phase I cap material in the cores collected in 2011 suggested that J9 was not included in the 1994 cover operation.

The Year 17 monitoring pointed to the J10 locations being physically stable, with target cover thickness achieved in two of the three cores. Of the three cores collected in 2011, J-10a and J-10c had cover thickness of 2.8 and 4.4 ft, respectively, while J-10b had 1.3 ft of cover material.

Physical stability measurements (i.e., bathymetric surveys) were not a part of the Year 22 monitoring (2017) monitoring. Observations made on the collected surface sediment samples suggested that the physical conditions had not changed since the previous 2011 monitoring. Two of the three J9 grab sample locations (J9-b3 and J9-b4) did not have any observable cap material, whereas one station (J9-c3) was principally composed of the Phase II/III cap mix. All three J10 discrete grab samples were principally the Phase II/III cap material. No evidence of Phase I capping material within any of the discrete sample locations in J9 or J10 was identified during the 2017 monitoring event.



4.3.2 Is the Cap in the Vicinity of J9/J10 Effectively Isolating the Underlying Contaminated Sediments?

Surface sediment analytical results for J9 and J10 are consistent with the results from the 2011 monitoring; no exceedances of the SQS/MCUL criteria for any of the measured chemicals of concern were identified.

In the 2011 J9 cores, NAPL was observed in all three discrete core samples within 1–2 ft bms. In 2011 core sample J9b, the criteria were exceeded in both the primary and shallow gradient samples (respective gradients are presented in Figure 1-4). In core sample J9c, no criteria exceedances were measured in the primary gradient sample. In the 2011 J10 cores, PAHs were measured in the primary gradient samples at J10a and J10c, but at concentrations below the SQS. The 2011 core J10c had detected PAHs that exceeded the 2LAET in the primary gradient samples, but not in the shallow gradient sample.

No evidence of hydrocarbons were identified in any of the 2017 J9 and J10 surface grab samples; core samples at locations J9 and J10 were not collected as part of the 2017 monitoring program.

4.3.3 Are Sediments in the Biologically Active Zone (0-10 cm) at J9 and J10 Remaining Clean Relative to the Washington State Sediment Management Standards?

The surface sediment samples appear to remain clean relative to SQS/MCUL criteria. While PAHs were detected in both composite samples collected within the J9 and J10 grids, the corresponding SQS/MCUL criteria were not exceeded for either sampling station.

4.4 Exposure Barrier System and West Beach Sediments

4.4.1 Is the EBS Physically Stable, Remaining in Place at a Desired Thickness?

The O&F determination of physical stability of the EBS is evaluated based on whether the 2 ft of placed fish habitat material at the EBS remains in place, and/or if the presence of NAPL in the EBS is identified. Three tools were used to provide the physical stability data: (1) direct field cover measures, (2) direct observations for the presence of NAPL, and (3) topographic surveys (hydrographic and photogrammetry) compared to the post-remedial construction (2008) elevations.

Direct Field Cover Measures

A minimum of 1 ft of fish habitat mix material is the relevant performance criterion. Nine locations from the 2011 survey were reevaluated in 2017. Three additional discrete locations in the upper intertidal were evaluated based on the apparent exposure of the underlying cobble layer (location H12-c3). The targeted stations were generally found to have 1 ft or greater of habitat mix cover. All three discrete stations on the east end of the EBS (H12-c3) were devoid of overlying cover materials (0 ft).

Presence of NAPL

NAPL was not observed along the lower intertidal shoreline, nor within any of the cores taken to 2 ft for chemical analyses within the EBS.

Topographic Surveys

Collectively, the lines of evidence from the survey program point to ongoing physical instability of the EBS cover material. Substantive erosion is shown in much of the EBS between post-construction (2008) and 2017. In some places, no cover is observed and the underlying cobble armor layer is exposed. The data suggest that erosion is ongoing and may not have stabilized. This conclusion is tempered however with considerable uncertainty relative to the comparability of the elevation survey data between the monitoring years, and by the fact that very limited direct-measurement data exists on EBS cover thickness.

Despite the loss of the habitat cover material, the underlying armor layer remains in place. Other observations provide evidence that the EBS cover remains an effective barrier to NAPL seeping and contaminant advection, and is a functioning habitat for benthic invertebrates (see Section 4.4).

4.4.2 Are Surface Sediment (2 ft) Chemical Concentrations in the EBS and West Beach Monitoring Locations Below the SQS/MCUL and MTCA Human Health Criteria?

The EBS is meeting its target sediment performance criteria for the protection of ecological organisms and for human health. Measured levels of COCs for the on-EBS intertidal samples were low, or non-detect; all results were below the corresponding SQS/MCUL criteria, as applicable. This includes the three discrete samples collected at H12-c3 (discretionary east station) where the sand cover had apparently eroded down to the cobble layer of the EBS. All intertidal surface sediment (2 ft) PAH results were below the ROD-specified human-health intertidal sediment concentration, and the Washington State MTCA B sediment criteria for the protection of human health.

4.4.3 Off-Exposure Barrier System Sampling Locations

Two grid locations were sampled on West Beach (D12 and E11), both west and off of the EBS. Grid D12 was a designated location in the FSP, while the sampling in grid E11 was determined in the field by Ecology (the “discretionary west” sampling location). While physical measurements were made at the six discrete off-EBS sampling sites, those two grid locations are outside the area comprising the EBS.

Chemical analyses results for the composites at both D12 and E11 were below the sediment criteria for the protection of ecological health (i.e., LAET and SQS, respectively). When compared to the human health criteria, D12 did not exceed any criteria, however the composite sample at grid E11 exceeded numerous individual compound-specific human health criteria and the ROD-established total HPAH concentration of 1.2 mg/kg dw.



4.5 North Shoal Subtidal Area Sediments

The objectives for the North Shoal subtidal sediments were to determine whether any surface sediment locations exceeded the SMS MCUL or 2LAET and if NAPL was present in any of the collected core samples.

4.5.1 Are Surface Sediment Chemical Concentrations in the North Shoal Subtidal Area Below the MCUL/2LAET Criteria?

For the samples collected in the offshore, subtidal area of the North Shoal, overall the COCs in the biologically-active zone are below the corresponding SQS/MCUL criteria. No exceedances for mercury or PCPs were identified in any of the composite samples.

Two grid composite samples (K8 and L8) had select individual LPAHs at concentrations that exceeded their corresponding SQS criterion but were below the MCUL/2LAET. The K8 composite result for acenaphthene was reported below the corresponding 2LAET criterion, but when normalized to the 0.67% TOC, the resulting value is above the corresponding SQS. Similarly for L8, the composite results for acenaphthene, fluorene, and phenanthrene were reported at concentrations below the respective 2LAET; however, when normalized to the TOC of 0.66%, the OC-normalized values for these three individual PAHs are above the corresponding SQS values.

The apparent SQS exceedances at K8 and L8 are identified only when the dry weight results are normalized to TOC 0.67% and 0.66%, respectively. The SMS does not require OC-normalization when the TOC is out of the range of 0.5% to 3.5%. It is worth noting that in replicate samples taken from the composite for J9, the reported TOC was 1.52% and 1.98%, a difference of 0.46% for the same sample. Given the low TOC for the K8 and L8 sample locations, the variability in TOC measures from the primary and replicate samples at J9, and that the dry-weight values for the individual PAHs were well below the corresponding LAET, the levels of acenaphthene, fluorene, and phenanthrene are at levels that would likely not pose risk to benthic organisms.

4.5.2 Is There Evidence of NAPL or Hydrocarbons in the North Shoal Subtidal Core Location?

No evidence of NAPL or hydrocarbons were identified in the subsurface cores collected at the North Shoal subtidal area coring locations. The OMMP target depth of 2 ft of surface sediment was achieved for all locations. Glacial till was present in all of the collected cores; the presence of NAPL was not noted in four offshore stations where the recovered sediment exceeded 3 ft (J7-c5, K7-c5, K8-c5, and L8-c5).

4.6 Clam Tissue Monitoring

The O&F determination for the intertidal areas evaluates whether the placed remedies provide functioning habitat, natural recovery, and whether shellfish are safe for human consumption. For this Year 22 monitoring, habitat use was not quantitatively evaluated. However, the collection of clams from West Beach in 2016 suggests that the ESB is providing functioning habitat. Natural recovery was specific to the North Shoal and East Beach, which were not evaluated as part of the Year 22 monitoring. Both of those

intertidal areas are under consideration for further remedial action in EPA's Proposed Plan.

In the 2016 collection, horse clams were collected at all four intertidal locations, including East Beach, North Shoal, Intertidal Cap, and West Beach. On East Beach and the North Shoal, more *Tresus nuttallii* species were found, compared to the Intertidal Cap and West Beach, where primarily *Tresus capax* were found. The availability of clams on West Beach was significant as clams were not found there during the 2011 sampling program. For the North Shoal, only a single clam was found.

To develop a background level of PAHs, horse clam tissue from a single clam was collected from Point No Point Park located on the northern end of the Kitsap Peninsula.

PAHs were measured in all clam composites collected at the EHOU intertidal areas; only indeno(1,2,3-cd)pyrene was detected in the reference area clams. Total cPAHs were highest in clam tissue at East Beach and North Beach, with moderately lower levels from the Intertidal Cap and West Beach locations. Clams at all locations in the EHOU had higher levels of cPAHs than the single clam collected and measured from reference site location.

USACE reports that in general, the B[a]P EQs calculated from the 2016 data were lower than those in 2011, but higher than 2014. The 2016 B[a]P EQs were generally higher than the 2014 B[a]P EQs at all sampling locations. In general, the B[a]P EQ values at the site do not have a definitive trend. The B[a]P EQs have varied throughout the 2011, 2014, and 2016 sampling events, at all locations on the beach (West Beach, Intertidal Cap, North Shoal, and East Beach).

The OMMP identifies a concentration of 0.12 µg/kg B[a]P EQ/TEQ as a target concentration in clam tissue that is protective of human health. All clam tissue B[a]P EQ/TEQ values from the EHOU, as well as the sample collected at the Point No Point background location, exceed this target clam tissue concentration. Based on the comparisons to this target tissue concentration, the O&F determination is that the intertidal remedies are not protective of human health.

The ROD amendment currently under preparation will not establish a specific cleanup level for clam tissue concentrations but will instead use shellfish target tissue levels to assess reduction in cPAH concentrations that would result from implementation of an effective sediment remedy. If EPA determines that a different sediment cleanup level and/or additional remedial action is needed to continue to reduce shellfish tissue cPAH concentrations for the purpose of achieving remedial action objectives, EPA will select those actions in the final ROD amendment.

5 Future Monitoring Recommendations

The following future monitoring recommendations are based upon the observations and O&F determinations from both the Year 17 and Year 22 monitoring events. Additional recommendations include establishing a baseline of environmental conditions against which future monitoring results will be evaluated after the planned remedial activities have been completed.

5.1 Monitoring Year 17 (2011) Recommendations

The following recommendations are carried forward from the Year 17 Monitoring Report (HDR and SEE 2012). These recommendations remain relevant for future O&F determinations and will inform the environmental baseline pre-remedial construction at the EHO.

- For the EBS, perform a systematic survey using grid-based measures of cover thickness. The cover-thickness survey should be performed twice a year (spring and fall) over the course of two or more years, to evaluate seasonality of sediment (cover material) movement. These data would be used to evaluate EBS stability and inform the need to conduct further maintenance on the EBS.
- For the EBS and Intertidal Cap areas, obtain intertidal and subtidal samples for grain size analysis to determine whether beach composition is changing over time. Evaluation of the data from both 2011 and 2016 suggests that material from the upper intertidal area of the EBS may be eroding; whether the EBS cover material is moving downslope or elsewhere is unknown at this time. In addition, Phase II/III habitat mix was identified in the subtidal stations of J9 and J10 in 2011, and then again in 2017 (as noted in this report).
- Conduct additional forage fish spawning and use surveys in November, February, and during the summer months to assess spawning areas and determine how adult fish are utilizing the EBS intertidal areas.
- Continue MNR monitoring at the designated areas of North Shoal and East Beach. The EPA's preferred alternative in the Proposed Plan (EPA 2016) for East Beach is active remediation (removal and reactive capping) for areas with NAPL present in the top 2 ft (~1.6 acres), and continued MNR at the remaining area (~9.2 acres). The North Shoal active remedial areas will require further delineation, but the working presumption is that some areas within the North Shoal will also have MNR as the selected alternative.
- Compile the existing physical, chemical, and biological survey information, and the construction report conducted in the intertidal/subtidal at OU1 into a single compendium and/or accessible location. In addition to these OMMP-related 5-Year review reports, numerous other studies have been conducted by multiple agencies that could be used to inform the post-remedial construction monitoring strategy. These include studies conducted by the National Oceanic and Atmospheric Administration/National Marine Fisheries Service on fish lesions, forage fish use of

Eagle Harbor, passive sampling of the Phase I cap, and past groundwater work completed by USACE under a grant from the Department of Defense (DoD).

5.2 Monitoring Year 22 (2016) Recommendations

These recommendations are based upon the observations and O&F determinations made resulting from the Year 22 monitoring activities.

- For the EBS, conduct systematic and seasonal physical surveys using grid-based measures of cover thickness. This recommendation, first made in the Year 17 monitoring report, remains relevant given the apparent loss of EBS cover material identified at EBS grid I12 (I12-e2), and the complete lack of cover material at the H12-c3 discretionary west sample location. At a minimum, establish complete east-west transects on 5 foot contour intervals (e.g., +10 to +15, +5 to +10, 0 to +5, and -5 to 0 feet MLLW) and take measurements every 50 feet (for a total of 20 cross-transect measurements). Seasonal surveys are recommended to provide information on potential erosive forces affecting the EBS (e.g., ferry wake, stormwater runoff), as well as the ultimate disposition of the cover material that has apparently been transported off the EBS.
- For the EBS and Intertidal Cap areas, obtain intertidal and subtidal samples for grain size analysis to determine whether beach composition is changing over time. This recommendation, also noted in Section 5.1, is relevant based on observations made during Year 22 monitoring activities.
- Conduct an additional multibeam and lidar survey at a minimum one-year after the 2017 bathymetric survey completed for this Year 22 monitoring event. Compare the resulting data to the 2017 data to determine if further erosion has occurred. Conduct additional comparisons between the methods used across the three different survey events to determine the actual degree of uncertainty associated with the elevation comparisons.
- During the upcoming 2017-2018 winter rain storms, physically inspect the EBS to evaluate the stormwater outflow including measures of flow, direction of flow, and any evidence of erosion due to the outflow.
- Continue sampling clam tissue from the intertidal areas of OU 1, while adding additional collection locations within Eagle Harbor for potential source comparison. The cPAH B[a]P EQ measurements from the 2011, 2014, and 2016 clam tissue surveys indicate the presence of cPAHs at all collection locations. The O&F determinations, based on these data, suggested that the existing remedies are not protective of human health. It is unknown whether the apparent exposure of clams is due to site NAPL exposure, or to other PAHs discharged to Eagle Harbor (e.g., boat diesel, upland stormwater runoff). Adding tissue sampling stations further west in the Harbor (e.g., Strawberry Plant Park Shoreline Restoration area) and south of East Beach (e.g., Pritchard Park East) would provide additional information that could help with the progression toward lifting of human health consumption advisories associated with OU 1.



5.3 Baseline and Long Term Monitoring Recommendations

These recommendations are in addition to the recommendations above, and are intended to develop baseline monitoring information against which future O&F determinations may be made. These specific recommendations are predicated on the assumption that the preferred alternatives in the Proposed Plan (EPA 2016) are effectively implemented.

- Complete a baseline elevation survey of the entire OU 1. This survey would include both a multibeam bathymetric survey and a site-wide photogrammetry survey. Comprehensive, OU 1-wide elevation surveys have not been completed since 2011. Site-wide elevation contours, as outlined under the current OMMP, serve as the initial basis for determining whether the existing remedies are physically stable.
- Complete a baseline passive sampling survey of the subtidal and intertidal remedial areas associated with OU 1 following the methods described in the joint EPA and DoD (2017) guidance. The passive sampling study (Thomas et al. 2012) completed on the Phase I cap provided data showing that while PAHs were identified on the cap surface, their presence was likely attributed to off-site sources and were not from vertical migration of PAHs up through the cap. Passive sampling devices have been recommended to support remedial actions that involve capping, enhanced natural recovery, *in situ* treatment, and MNR (Exponent and SEE 2016).

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Appendices

(Provided on CD)

- A Final 2016 Operations, Maintenance, and Monitoring Plan Addendum
- B Final 2016 Quality Assurance Project Plan
- C Data Report, Wyckoff/Eagle Harbor, Evaluation of Sediment Cap Condition at East Harbor Operable Unit, Integral Consulting, Inc., 2014
- D Clam Tissue Collection and Reporting
- E Field Monitoring and Daily Reports
- F Core Logs and Photographs
- G ARI Analytical Laboratory Reports
- H Data Validations Reports
- I Survey Program Technical Memorandum (hard copy included)
- J Response to Comments on Draft Report

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